COSTS AND RETURNS OF BULK MILK TANKS ON DAIRY FARMS IN THE OKLAHOMA CITY MILKSHED

By

FRED ALLEN MANGUM, JR.

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North Carolina State College

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Thesis Approved:

Kenneth B. Boggs
Thesis Adviser

Leo V. Blakley

Robert MacVicar
Dean of the Graduate School

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CHAPTER I

INTRODUCTION

Bulk pick-up of milk at the farm is a relatively recent technological development and is an important force altering the combination of resources within dairy farms. Evaluating and deciding for or against such alternative resource combinations is a continuing decision making process.

It is recognized that the adoption of a bulk milk handling system is only one of many alternative uses for capital. For example, an individual could invest his capital in additional cows, machinery, land, or other enterprises. This study will not attempt to evaluate these alternatives. Rather the primary purpose is to provide farmers with a guide by which they can estimate their own situation and determine the additional costs and returns from the utilization of a bulk system.

Since the introduction of bulk handling in the Oklahoma City market in May, 1955, management has been faced with a choice between the older can system or the bulk system. One criterion of choice is returns over cost. Costs are usually expected to vary with the size of farm and also the methods of operation. Converting to the bulk tank system can be accomplished most efficiently if estimates of cost and returns associated with the installation and operation of bulk tanks on various size farming units are known.

Objectives

In order to aid farmers in decision making with reference to conversion to the bulk tank system, this study has been designed specifically to: (1) investigate the characteristics of Oklahoma dairy farms now using a bulk tank; (2) estimate the relationship between volume and costs for these farms and the volume necessary for savings from the tank to exactly offset costs of the tank; and (3) estimate the relative profit position of Oklahoma dairy farms at various volume-output levels.

The analysis may furnish useful information to farm managers insofar as returns over cost form a criterion for choice between a can or bulk system. In addition to its usefulness to dairymen as a decision making tool, the results should serve as a guide in evaluating the soundness of a bulk tank loan from the standpoint of credit institutions.

While several similar studies have been conducted in other states, these studies were designed to compare cost of installing and operating a bulk system with the cost of a can system. No specific consideration was given to the level of production at which added returns from converting to a bulk tank would exactly offset the added cost.

Assumptions and Limitations

The assumptions made in this study were: (1) the costs of producing fluid milk were equal under a bulk or can system; (2) dairymen were profit motivated; and (3) the observed farms were operating efficiently and each was observed at a point on its short run cost function that was tangent to the long run cost curve.

Application of the findings of the study are limited to the Oklahoma City milkshed or to areas with similar farm characteristics and cost structures. Since information from the farm sample was obtained by personal interview, the accuracy of the results is limited to the reliance that may be placed on this method.

Area and Time of Study

Information for the study was obtained primarily from a representative sample of dairy farms. The area of the survey was that commonly defined as the Oklahoma City milkshed and is shown in Figure 1. The area includes parts of 25 counties. There were 1,331 Grade A dairy farms shipping milk to Oklahoma City in March, 1957. Since the area differs widely in soil type, topography, and farm organization, the sample was designed to insure complete coverage of the area.

The survey was conducted during the summer of 1958. Information was obtained for the calendar year 1957. This year was one of relatively large rainfall and excellent grazing conditions. Milk sales per farm may be somewhat greater than normal as a result.

In this study the problem was to provide estimates of the annual costs and savings associated with the use of a bulk milk system. Using these estimates within a specified framework, the level of output of milk per farm can be determined at which added costs from this system are equal to possible added returns. Dairy producers, using this information as a guide, can determine for themselves the advantages or disadvantages in converting to a bulk handling method. Attempts were also made to estimate the relative profit position of dairy producers at five levels of production and the effect of converting to a bulk system.

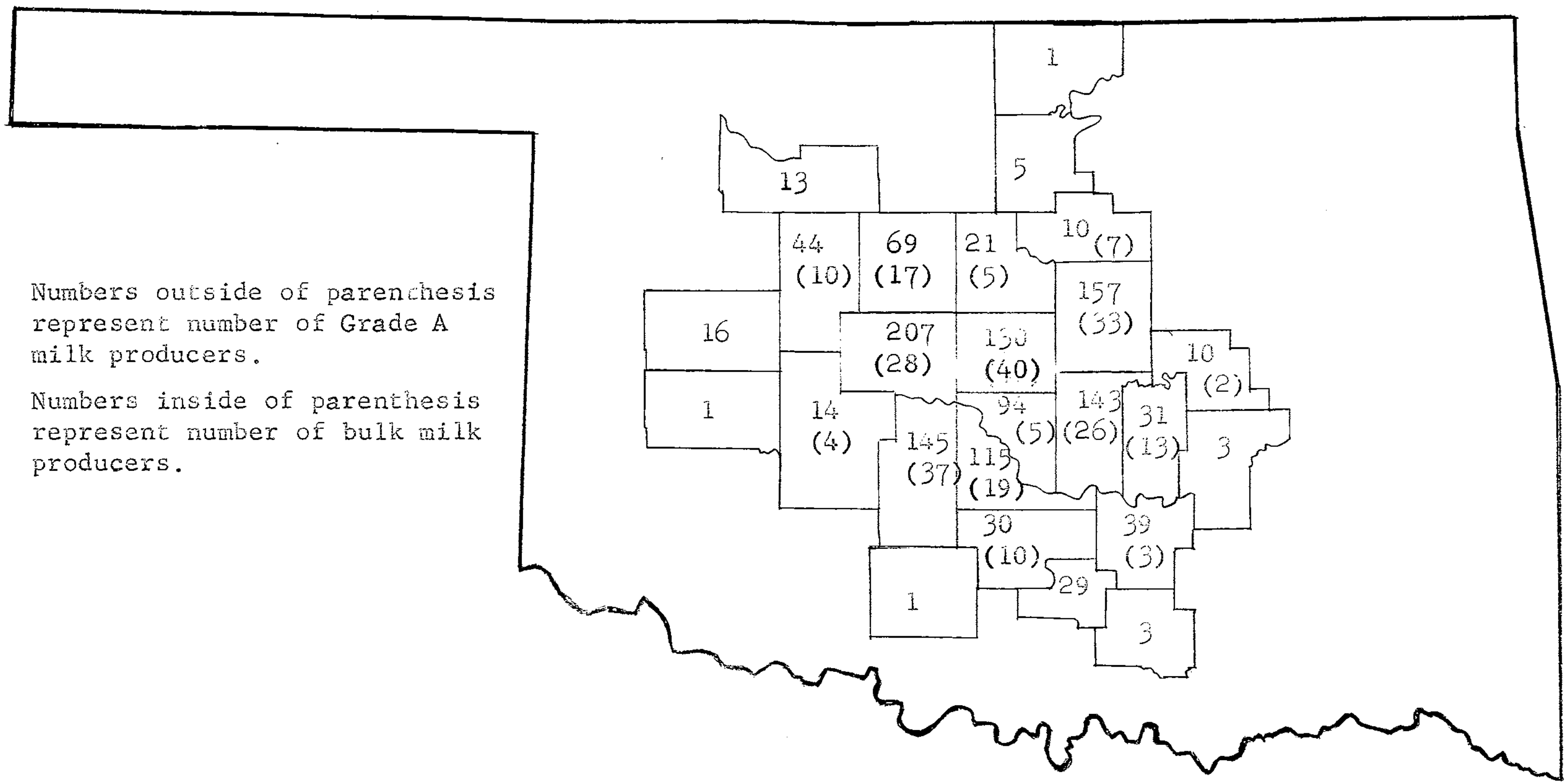

Figure 1. The Oklahoma City Milkshed, March, 1957

Source: Marketing Service Information, Oklahoma City Marketing Administrator, AMS, USDA, (April, 1957).

CHAPTER II

PROCEDURE

The problem of obtaining reliable estimates of cost functions may be approached by budgeting from relevant production and price data or by observing cost and volume data from a representative sample and then deriving a synthetic cost function. The former method has many advantages when complete and accurate cost data may be obtained on all the component parts of a production operation. In the absence of such data, estimates of the long-run average cost curve may be obtained by observing a stratified sample of production operations at different levels of output. For purposes of this study the latter procedure has been adopted.

Since the Central Oklahoma Milk Producers Association provides the only bulk milk transportation service in this area, all bulk producers selling milk on the Oklahoma City market are members of the Association. Information on farm characteristics and the cost of installing and operating a bulk tank was obtained from a sample drawn from this population of dairy farms. This information was supplemented with data from the records of the Central Oklahoma Milk Producers Association, the Oklahoma Metropolitan Milk Marketing Administrator, and various bulk tank manufacturing and distributing concerns. Total milk sales per farm were also obtained from the Association. Information used in estimating the feed and labor cost per farm was based on previous research at Oklahoma State University.[1]

Selection of the Sample

Dairy farms in the Oklahoma City milkshed are characterized by extreme variations in size, productive resources, physical composition, and management levels. In addition, there has been considerable influx and outgo of dairy producers in this area. Changes in the relative profitableness of dairying with respect to beef production may account for much of the turnover among dairy farmers.[2] For these reasons the sampling procedure adopted is an attempt to eliminate the influence of factors other than those under direct consideration.

The universe to be sampled was limited to those dairy producers with bulk tanks selling milk on the Oklahoma City market as of January, 1958. Sales of milk per farm since May, 1955, the date that bulk hauling was initiated in this area, were obtained from the Association. To avoid possible bias from the inclusion of a relatively short time producer, this population was restricted. In order to qualify as a potential sample unit, a farm must have been producing Grade A milk commercially in the Oklahoma City milkshed for a minimum of two years prior to January,

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[1]F. L. Underwood, Economic Survey of Resources Used by Dairy Farmers in Oklahoma, Agricultural Experiment Station Bulletin No. B-482 (Oklahoma State University, December, 1956) p. 19.

[2]Leo V. Blakley, Producer Adjustments and Opinions Under Federal Order Pricing of Milk in the Oklahoma City Milkshed, Agricultural Experiment Station Bulletin No.B-479 (Oklahoma State University, September, 1956) p. 8.

1958. By this definition, the population of bulk tank dairy farms in the universe to be sampled was 210 or 58.6 percent of all bulk producers in this area.

Based on earlier studies of this milkshed and actual observations of land resources, it was assumed that there could be significant differences in farm organization in the eastern half of the milkshed compared with the western half. These differences might suggest separate treatments in the course of the study. Because of this assumption an arbitrary dividing line, Highway 77, extending north-south through Oklahoma City was selected. Such a division would avoid the possibility of a sample being drawn exclusively from either the east or west side of the milkshed. Following this procedure, 96 farms were located on the east side and 115 farms were located on the west side of this arbitrary dividing line.

Further stratification of the sample was necessary in order to provide reasonable estimates of bulk tank costs associated with different levels of milk production. The 210 farms in the population were divided into five separate groups (A through E) based on the average pounds of milk produced per month during the calendar year of 1957.

Because this study is concerned primarily with estimating costs of bulk milk tanks at different levels of output, no attempt was made to draw the sample in proportion to the population of specific stratifications. To insure approximately equal coverage by size, ten schedules were selected from each of the five groups. Farms of the eastern half of the milkshed were arrayed first and those in each strata of the western half were then arrayed. Probability sampling was assured by assigning each farm a number and then selecting a number at random. By systematically sampling the remainder of the farms in each strata, the number of farms in each size group was proportionally allocated according to the total number in the two areas.

The total sample consisted of 50 farms, 21 in the eastern half of the milkshed and 29 in the western half of the milkshed. In group A there were only ten producers. All of these were included with no alternates. There were 48 possible sampling units in group B, 61 in group C, 64 in group D, and 27 in group E. Ten farms were selected from each of these groups and five farms were randomly selected as alternates in each group. Schedules were taken by the personal interview technique from the dairy operator. A total of three calls per farm was allowed before an alternate was substituted.

Method of Estimating Costs

The long-run average cost curve is emphasized in this study. This is the cost curve that is just tangent to all possible short-run average cost curves and shows the least possible cost per unit of producing various outputs when the firm has time to build any desired scale of plant. The long-run average cost curve has often been termed the expansion curve since in the long run all factors are considered variable. This expansion curve shows the levels of cost that may be expected from the operations of firms of various sizes, and assumes that operations are organized as efficiently as possible under given conditions. This concept is particularly applicable to this analysis since it shows that the possibility of lowering cost per unit by the adoption of a technological innovation is greater as the size of farm operation is increased.

Eight components of the total cost of installing and operating a bulk milk tank were computed for each of the 50 farms in the survey. All costs were expanded to an annual basis. Fixed costs, those costs incurred independent of output, included depreciation, costs of investment, taxes, and insurance. These were summed and amortized over a 15-year period which was comparable with the life of the tank. Variable costs, those costs that change with output, included electricity, repair, and materials and labor used in cleaning the tank. Variable costs for each farm were computed for the 1957 farm output of milk. Total cost per farm was the sum of fixed and variable costs. Total cost divided by the sales of milk per farm in 1957 yielded the average total cost per hundredweight.

The long-run average cost curve used in this analysis was derived by least squares regression using the average total cost per hundredweight as the dependent variable and volume of milk per farm as the independent variable. This procedure illustrates the average relationship between cost per farm and volume of output, and provides an estimate of the cost per hundredweight of using the bulk tank at any given level of production.

A serious limitation to this procedure is that it correctly estimates the long-run average cost curve only when each farm studied is observed at a point on its short-run cost curve that is tangent to the long-run average cost curve.[3] The synthetic curve therefore is not an average cost curve in its strictest sense, but closely approximates what the

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[3]Richard Phillips, "Empirical Estimates of Cost Functions for Mixed Feed Mills in the Midwest," Agricultural Economics Research, Vol. VIII, No. 1, January, 1956, p. 3.

average cost curve would be. Heady points out that in studies of this nature, some farms are included which operate at the low point of the short-run average cost curve and others to the left or right of this point.[4] Therefore, regression analysis, as an averaging device, provides estimates of neither short-run cost curves nor the long-run expansion curve, but of a synthetic curve with essentially the same parameters as the expansion curve, but lying above it. In spite of these limitations, estimates provided by this procedure can be used to suggest the cost structure associated with different levels of production and different sizes of bulk milk tanks. In particular, these estimates show the average relationship between cost per unit and output, the long-run size which gives the lowest cost, and the absolute decline in costs as different outputs are attained.

Information from the producer survey supplied data for an estimate of average revenue that could be imputed to the bulk tank. Comparison of this extra revenue with the extra cost presented an opportunity to make an estimate of the net returns from conversion for each of the different levels of milk production. Further analyses, omitting the effect of the bulk premium and savings in hauling cost on the break-even volume, have also resulted from this procedure.

Using data from previous research in this same milkshed, an estimate of net profit for each of the five strata was obtained. An annual per cow cost of feed, pasture, and direct labor was derived from previous

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[4]Earl O. Heady, Dean E. McKee, and C. B. Haver, Farm Size Adjustments in Iowa and Cost Economies in Crop Production for Farms of Different Sizes, Agricultural Experiment Station, Research Bulletin 428, (Iowa State College, May, 1955) p. 434.

research data and applied to the average number of cows in each of the groups. Because the cost data were relatively limited, it was necessary to assume linearity for all size groups. This supplied an estimate of the cost of milk production at each of the five levels of output. Revenue was determined on the basis of milk prices received and sales of milk per farm in 1957. The difference between these two estimates provided an estimate of the annual net profit per farm. This procedure permitted an estimate of the effect on net revenue of adding a bulk milk tank at each of the five levels of production.

CHAPTER III

BULK MILK HOLDING TANKS

The bulk milk tank is a covered, insulated, refrigerated, stainless steel vat which is used for cooling and storing fresh fluid milk. It is used primarily on commercial dairy farms producing Grade A milk. These tanks are designed to maintain milk temperature at about 38 degrees Fahrenheit. Classifications of bulk tanks may be made on the basis of heat removal systems, design, condensor cooling methods and location, and exterior finish.

Bulk Tank Heat Removal Systems

In the process of cooling milk in a bulk tank, heat may be removed directly or indirectly. In direct heat removal, the heat moves from the milk directly to the refrigerant material in the refrigeration system without the use of other fluids. With indirect heat removal, the heat may be absorbed first by ice water which is cooled by the refrigerant in the system. The heat is then transferred from the water to the refrigerant material.

Direct Expansion Tanks

This type of tank gets its name from the method used to remove heat from milk, that is, direct heat removal. In this study 49 of the 50 Oklahoma dairymen interviewed were using the direct expansion type tank. This appears to be fairly representative of Oklahoma dairymen. The

Oklahoma Agricultural Extension Service reported 264 direct expansion tanks and only three ice-bank tanks in use in the Oklahoma City Marketing Area as of January 1, 1957.[1]

In the direct expansion system, Freon 12 is the refrigerant. This gas, when compressed, forms a liquid and cooling is accomplished by absorbing the milk heat directly. As the liquid is pumped through coils welded between the inside lining and the exterior wall of the tank, contact is made with the heat of the milk in the tank. As the refrigerant absorbs the milk heat, it is converted from a liquid to a gas. The compressor and condenser then compress and cool the gas so that it becomes a liquid again and is ready for reuse. The heat is transferred to the air and the cooling process may be continued.

Figure 2 illustrates this tank and its essential operating features: the control panel with thermometer and thermostat; the condensing unit, containing the condenser, compressor, and compressor motor; and the agitator and motor.

From two to four electric motors are usually found on this type of tank. Since the direct expansion tank does not store refrigeration capacity, but cools by direct contact with the refrigerated tank wall, a relatively large compressor and compressor motor is required. Generally, the compressor motor ranges from two-thirds to one horsepower per 100 gallons of daily milk capacity. There is an agitator motor of

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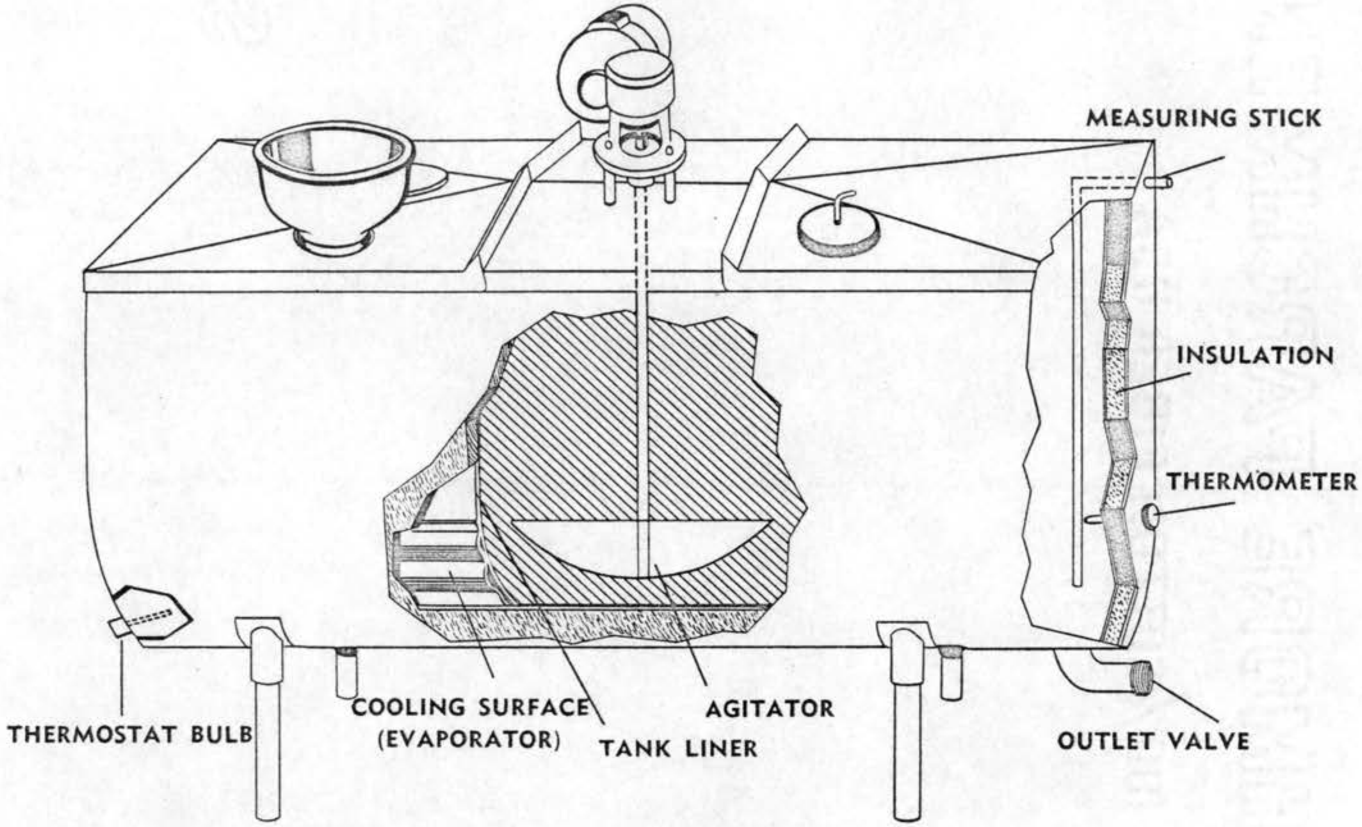
[1] Carl W. Hall and Donald L. Murray, Bulk Milk Handling, Proceedings of National Conference on Bulk Milk Handling (Michigan State University, May, 1957) p. 127.



A DIRECT EXPANSION TYPE TANK

Figure II. Illustration of a Direct Expansion Bulk Milk Tank approximately one-sixth to one-third horsepower. This motor on all models is automatically activated when the compressor is running, and on some tanks a time device turns the motor on for five minutes each hour. Most tank models have a manual control on the agitator to permit mixing of the milk when taking a sample. If the condensing unit is air-cooled there will be one or two motors, approximately one-eighth horsepower each, operating the condenser fans.

The presence of the comparatively large compressor motors adds directly and indirectly to the cost of the tank. The initial cost is approximately 10 percent greater than the ice-bank type. Indirectly, it contributes to a higher installation cost since the direct expansion tank usually requires the additional expense of larger switches and additional wiring for the milk house.

Offsetting some of this expense is the relatively low electrical consumption rate of the tank. Because of the larger motor, cooling of the milk is accomplished in a relatively short period of time. As a result, the direct expansion tank usually requires about one-half kilowatt hour less per hundredweight of milk cooled than is required for the ice-bank tank. A Michigan State study found that when operating at full capacity, the compressor runs an average of three to six hours per day or 13 to 25 percent of a 24 hour day.[2] It was the opinion of Oklahoma farmers that the compressor in normal farm use runs only an average of 3.4 hours per 24 hour day.

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[2]D. L. Murray, et.al., Handling Milk in Bulk on the Farm, Cooperative Extension Service Bulletin No. 342 (Michigan State Extension Service, May, 1957) p. 14.

With the direct expansion tank the overall cooling rate is faster than the ice-bank tank. This system has a relatively slow cooling rate when milk first enters the tank, but cools faster as the temperature drops. Milk may be cooled from 95 degrees to 38 degrees in approximately 130 minutes.[3]

There are two disadvantages associated with this tank. First, there is a danger of milk freezing. Farmers encountering freezing usually experience this trouble when milk is first emptied into the tank or when only a small amount is being cooled. To avoid this problem, the tank must be equipped with accurate and reliable thermostats, expansion valves, and suction valves. A second problem is presented in the event of a power failure. If this should occur there will be no cooling for the duration of the failure. However, full cooling will be effected as soon as the power is restored.

Ice-Bank Tanks

These tanks have also acquired their name from the process used in cooling milk. With this tank the actual cooling is done indirectly by an ice bank rather than directly by the refrigerant and the condensing unit. The refrigerant creates a bank of ice by the removal of heat from water and this ice bank cools the milk as it enters the tank. As the heat is transferred to the ice bank the ice melts and the cycle is repeated.

Figure 3 illustrates the essential characteristic of this tank. It has the same operating features as the direct expansion tank plus

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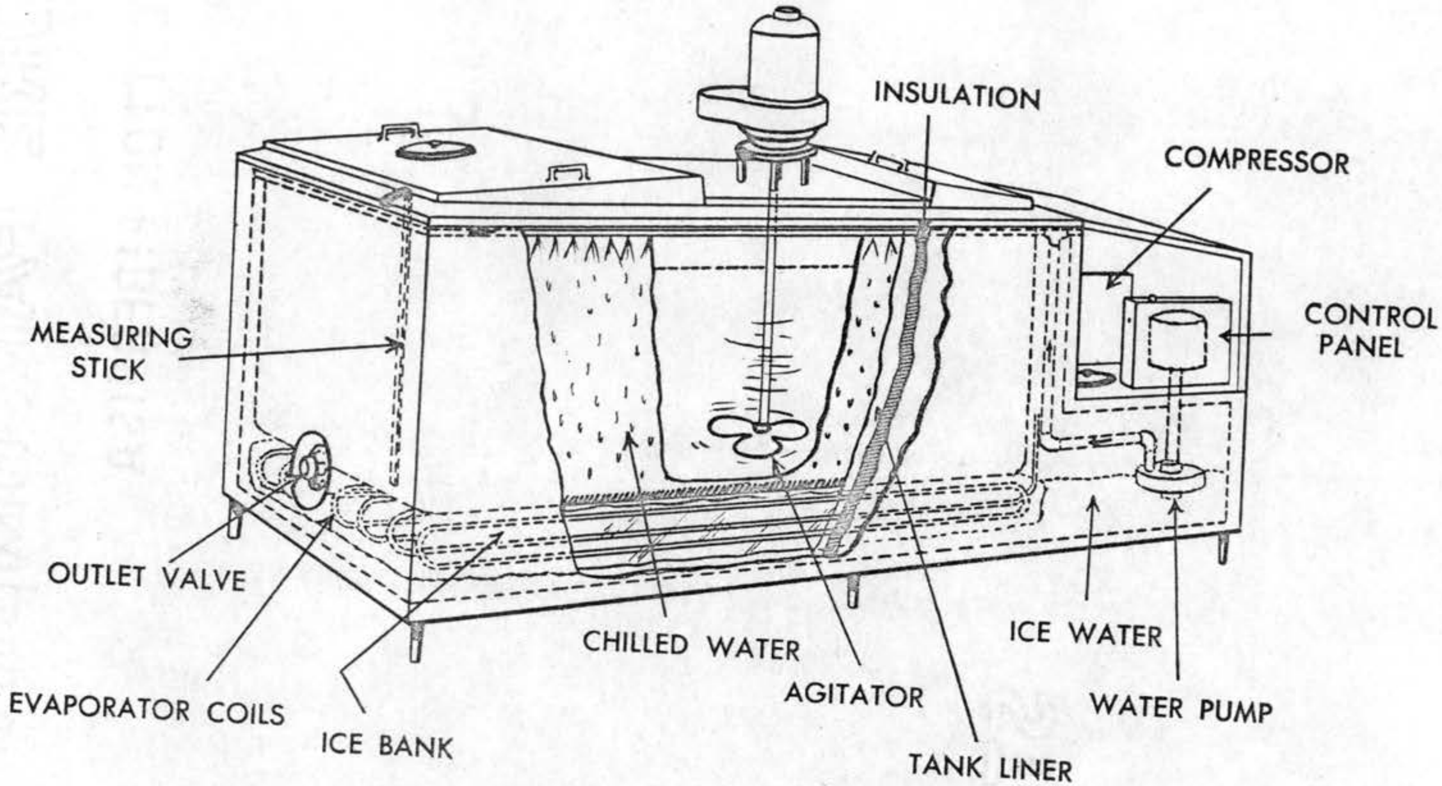
[3]Carl W. Hall and Donald L. Murray, p. 42.



AN ICE-BANK TYPE TANK

Figure III. Illustration of an Ice-Bank Bulk Milk Tank evaporator coils for forming the ice bank, pipes and jets for carrying the water, and the water pump. For top efficiency there should be a thin layer of ice surrounding the coils when the milk reaches 38 degrees.

From three to five motors are on this tank. In addition to those listed for a direct expansion tank, there will be a motor of approximately one-fourth to one-third horsepower operating the water pump. It is the function of this pump to carry the chilled water to the top of the tank where it either is sprayed or flows by gravity over the inside lining of the tank.

The ice bank provides a reserve of cooling capacity. Because of this, the tank requires a relatively small motor and compressor unit. The size of the compressor motor will be between one-third and one-half horsepower per 100 gallons of daily milk capacity. For example, a 300 gallon tank will have a one to one and one-half horsepower motor on the compressor. Building the bank of reserve ice causes the compressor and motor to run a longer period of time than for the direct expansion tank. In rebuilding the bank of ice the compressor runs from 12 to 20 hours per day or 50 to 83 percent of a 24 hour day.[4]

Since the compressor operates over a longer period of time, it has a lower peak load demand, that is, the maximum electrical power required at a given time is considerably less than for the direct expansion tank. At milking time there are many other farm and home electrical appliances being used. The total result is likely to be less strain on power lines

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[4]D. L. Murray, et al., p. 42.

during this critical period. As a result electric companies may recommend this type of tank, particularly in areas where a relatively large number of bulk tank dairy farmers are concentrated on the same electrical line facilities.

The ice-bank tank has a relatively fast cooling rate at high milk temperatures. When milk is emptied into the tank it is cooled to a temperature of 50 degrees in 60 minutes. From 50 degrees to the holding temperature of 38 degrees the cooling rate is not as rapid as for the direct expansion tank.

Since the entire tank wall is cooled, condensation of water may occur on the inside upper walls. This can be a serious disadvantage if these droplets fall into the milk and cause odors to develop. A second disadvantage, which applies particularly to Oklahoma conditions, is the formation of scale inside the tank walls. This occurs as the result of minerals in the water. For this reason it is generally assumed that the useful life of the ice-bank tank will be comparatively shorter than for direct expansion tanks.

Bulk Tank Design

A second method of classifying bulk holding tanks is by the design and construction of tanks for milk storage. A tank having an unsealed or non-air tight removable lid or cover and which is filled by dumping or piping milk through a strainer located in the lid, is of the atmospheric type. A newer and perhaps simpler system, generally used with a pipe line milker, is the vacuum tank. This tank has an air tight or sealable lid or cover which is held in place by vacuum pressure during the milking operation.

Atmospheric Tanks

The atmospheric pressure tank may be of any shape and the refrigerant system may be ice bank or direct expansion. Of the 50 producers interviewed in this study, 46 were using this type tank. The large number of these tanks may be explained in part by the fact that the vacuum tank is relatively new and the association did not recommend it until recently.

Vacuum Tanks

The vacuum tank is rapidly growing in favor with Oklahoma dairymen. The Central Oklahoma Milk Producers Association has indicated that the current rate of installation of these tanks exceeds that of the atmospheric type. The vacuum tank must be round to withstand the pressure. The lids are fitted with gaskets to maintain the vacuum at 13 to 14 inches of mercury. The cost of this tank is slightly greater than the cost of the atmospheric pressure type tank.

The vacuum tank is more easily adapted to a system of pipeline milking since the vacuum maintained on the tank is the same as the vacuum maintained on the milking line. Milk may move directly from the cow, through the line, and into the tank. This eliminates the need for the vacuum releaser used with an atmospheric type tank and offers a definite advantage to farmers planning the installation of a pipeline system.

Condenser Cooling Methods and Location

The condensing unit consists of a compressor and motor, a condenser, and a receiver. The condensing unit size is a function of the quantity of milk cooled and the cooling rate rather than tank size only. The compressor should have the capacity to cool the first milking to below 50 degrees Fahrenheit within one hour after milking is completed and down to 40 degrees in the second hour. It should be of sufficient size to hold the blend temperature of subsequent milkings below 50 degrees at all times.

Condenser Cooling Methods

There are three different types of condensers available for use on bulk tanks: air cooled, water cooled, and a combination of air and water. Generally, air cooled units are installed on ice-bank tanks and small direct expansion tanks. Although air-cooled units are most appropriate for use with small condensing units, they are available on systems as large as five horsepower. This type unit is the simpliest mechanically, needs the least attention, and is most easily installed. Air cooled condensers and motors are designed in the ratio of one horsepower per 100 gallon tank capacity for milk collected every day. Without adequate ventilation, the hot air surrounding the air-cooled unit increases the compressor running time, the load on the motor, and consequently the cost of operation. The surrounding air should be free of dirt and dust. Otherwise, the condensing unit should be cleaned frequently to avoid a sharp decrease in efficiency.

Cooling the condenser by a combination of air and water increases the efficiency of the unit and decreases the operating costs. In experiments conducted at the Pennsylvania Experiment Station, a saving of .515 kilowatt hours per hundredweight of milk cooled was achieved after the unit had been converted from air cooling to air and water cooling.[5]

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[5]Carl W. Hall and Donald L. Murray, p. 41.

In addition, the cooling rate of the first milking was faster and there was a smaller temperature rise at subsequent milkings.

Combination air and water condensers are used on bulk tanks ranging in size from 150 to 1,000 gallons. They are most advantageous where the water supply is adequate and where there is a ventilation problem. Usually these units are run on air and water in the summer and air alone during the winter. In winter the water is drained from the unit to prevent freezing. The systems uses an average of two gallons of water per gallon of milk cooled when the water cooled section is in operation.

Water cooled condensers are most often used on tanks of five horsepower capacity and over. They require from one to two and one-half gallons of water per minute for each horsepower rating of the compressor motor. It is important that the supply of water be adequate and free from salts that might collect inside condenser coils. Experimental evidence indicates that this type condenser uses less kilowatt hours per hundredweight of milk cooled, the initial cooling rate is faster, and subsequent temperature rises are the least of the three methods.[6]

Water cooled condensers need periodic cleaning to remove deposits of water scale which cause a decrease in efficiency of the unit. The required frequency depends upon the degree and type of hardness in the water. In areas where the water is very hard the use of water cooled condensers should be avoided.

Location of Condenser Units

For tank sizes of 500 gallons or less, producers usually have an option as to whether the condensing unit shall be attached directly to

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[6]Ibid.

the tank or installed separately. The attached unit is slightly less expensive initially and is easier to install. However, it delivers the milk heat into the milkroom and adequate ventilation must be provided if the unit is to operate efficiently.

The remote installation has the condenser mounted outside the milkroom. This is available on all but the smaller tank sizes and is usually the only alternative for tank sizes larger than 500 gallons. The Central Oklahoma Milk Producers Association requires a small protective housing over all units installed outside the milkroom. This is to prevent weather damage and is necessary for insurance coverage. The house should be large enough to permit intake and exhaust of air.

Exterior Tank Finish

The exterior wall of the tank may be stainless steel or painted. In either case all surfaces in contact with the milk are of stainless steel. The cost of the stainless steel tank is approximately 10 percent greater than the painted tank. Despite this higher cost, 45 of the 50 Oklahoma dairymen interviewed were using stainless steel tanks. Only one brand of the painted steel tank was found in the study and tanks of this type were among the first installed in the milkshed.

The useful life of the painted tank is not expected to be as great as the all stainless steel tank. C. N. Turner conducted a field study on 120 bulk tanks of which 53 were stainless steel and 67 were painted steel.[7] He found all the stainless steel surfaces to be in excellent

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[7] C. N. Turner, "Bulk Milk Cooler Field Studies," Agricultural Engineering, Vol. 38, No. 2, (February, 1957), p. 94.

condition, but 19 of the painted steel tanks showed varying degrees of chipping, peeling, and wear that frequently resulted in rusted spots. In addition, rust was often found over welded material used to join seams, hinges, and various parts of the tank components. Rusty areas were also common on the underside of painted tanks near the milkhouse floor. These conditions are considered undesirable from a maintenance cost point of view and also reflect unfavorably upon the tidiness and sanitary conditions as viewed by the the public health inspector.

CHAPTER IV

CHARACTERISTICS OF FARMS WITH BULK MILK TANKS

The costs of owning and operating bulk tanks were developed from the sample of bulk milk producers. The present chapter presents the structure of farm organization and the dairy enterprise for these producers in order to provide a better understanding of the economic environment within which bulk tanks are installed and used. Consideration will be given to resources available, enterprise combinations, sizes of tanks in use, problems associated with bulk tanks, and changes either made or anticipated after installing the bulk tank.

Farm Resources and Enterprise Combinations

Half of the farmers in the sample reported that 90 percent or more of the total farm income was derived from dairying.[1] Five farms reported less than 50 percent of farm income from the dairy enterprise. The average income reported for all farms in the survey from dairying was 76.2 percent of total farm income.

Farm Size

The 50 farms in this study averaged 550 acres per farm. These farms ranged in size from 76 to 3,030 acres. Farms in the east were larger than those west of Oklahoma City. The eastern farms averaged 709 acres compared with an average of 415 acres per farm in the west. Almost half

[1]Includes sales of cattle and calves.

of the farms in the survey (21) contained more than 500 acres (Table 1). As might be expected, farms with relatively low annual milk production had the smaller acreages. Half of the farms in the two lowest producing groups contained less than 300 acres. All but two of the twenty farms averaging greater than 20,000 pounds of milk per month contained more than 400 acres.

Land Use

The proportion of land devoted to pasture exceeded all other uses in 1957. Dairymen on the 50 sample farms reported that some grazing was obtained on 441 acres per farm. This was an average of 80.2 percent of the total land in these farms (Table II). Although the absolute number of acres devoted to pasture varied greatly between groups, the acreages expressed as a percentage of total farm land were similar except for group A. The 201 acres in pasture on group A farms averaged only 64.8 percent of land in the farm.

Grazing was obtained from five principal sources. The most common was native open pasture (Table II). Native improved pasture was used by about half the farms. Woodland pasture, found mostly in the eastern area, was used by 62 percent of all farms for "some grazing". Temporary pasture was used by 72 percent of the farmers to supplement permanent pasture. In most cases crops used for this purpose were sorghum, sudan, or some combination of oats, wheat, barley, and sudan. Harvested cropland was pastured by 78 percent of the farmers and usually consisted of wheat, oats, or sorghum grazed during the winter or spring and later harvested for grain.

Table I

Ownership, Acreage, and Size Distribution of Dairy Farms in Sample, Oklahoma City Milkshed, 1957[a]

Item	Total		Group A 0-10,000 lbs.		Group B 10-15,000 lbs.		Group C 15-20,000 lbs.		Group D 20-30,000 lbs.		Group E > 30,000 lbs.	
	Farms Reporting	Avg. Acres	Farms Reporting	Avg. Acres	Farms Reporting	Avg. Acres	Farms Reporting	Avg. Acres	Farms Reporting	Avg. Acres	Farms Reporting	Avg. Acres
Ownership												
Rent	17	255	4	259	3	133	4	235	3	507	3	147
Lease	19	400	2	280	5	308	3	322	3	370	6	569
Own	39	400	7	215	7	204	8	689	8	376	9	459
Total acres	50	550	10	310	10	337	10	742	10	564	10	799
Size Distribution												
Acres less than 100	1		1		0		0		0		0	
100-199 acres	5		1		3		1		0		0	
200-299 acres	6		4		2		0		0		0	
300-399 acres	8		2		1		3		2		0	
400-499 acres	9		1		2		2		2		2	
Over 499 acres	21		1		2		4		6		8	

[a]Averages in all cases are computed on the basis of number of farms reporting.

Table II

Land Use on Farms in Sample, Oklahoma City Milkshed, 1957[a]

Item	Total		Group A 0-10,000 lbs.		Group B 10-15,000 lbs.		Group C 15-20,000 lbs.		Group D 20-30,000 lbs.		Group E ≥ 30,000 lbs.	
	Farms Reporting	Avg. Acres	Farms Reporting	Avg. Acres	Farms Reporting	Avg. Acres	Farms Reporting	Avg. Acres	Farms Reporting	Avg. Acres	Farms Reporting	Avg. Acres
Total Pasture[b]	50	441	10	201	10	274	10	632	10	458	10	640
Native-open	44	195	8	81	10	115	10	360	8	197	8	202
Native-improved	26	99	4	71	4	25	5	120	6	74	7	162
Temporary	36	74	8	32	8	41	4	45	7	50	9	172
Woodland pasture	31	110	5	29	3	109	6	158	8	141	9	97
Harvested cropland pastured	39	123	7	97	9	92	7	141	7	155	9	136
Cropland	47	224	10	180	9	174	10	208	8	275	10	288
Wheat	35	91	8	72	6	108	6	146	8	93	7	47
Cotton[c]	17	17.9	5	18.2	2	6.0	5	17.0	3	13.0	2	38.0
Sorghum	31	37	6	30	5	25	6	44	6	35	8	45
Oats	29	68	7	54	6	40	3	92	6	65	7	98
Barley	10	32	2	40	2	29	2	23	4	34	0	-
Alfalfa	19	44	5	32	4	13	2	31	4	42	4	100
Corn	10	57	2	9	1	75	0	-	3	64	4	71
Sudan	13	32	3	23	5	28	2	28	1	45	2	50
Others	24	67	4	37	6	53	4	59	3	53	7	107

[a]Averages in all cases are computed on the basis of number of farms reporting.

[b]Includes harvested cropland pastured.

[c]Includes cotton acreage in soil bank in 1957.

An average of 224 acres was planted in crops on 47 farms in 1957. This was 40.7 percent of the total land in these farms. The three farms reporting no cropland were in the extreme eastern half of the milkshed.

Farms in group A reported the largest relative amount of land in crops. Cropland in this group averaged 58.1 percent of total acres in these farms, or 180 acres per farm. Farms in group C reported the smallest percent of cropland but this reflects the influence of one large farm which was primarily in pasture. Farms in group E averaged only 36 percent of the total land in cropland.

Wheat was grown on more farms and in larger quantities per farm than any other crop. Farmers reported an average of 91 acres per farm devoted to this enterprise. Cotton was grown on 17 farms but 14 of these reported the 1957 cotton acreage either in the soil bank or sold to someone else. All other crops reported were grown as feed crops. Grain sorghum and oats were reported on most farms. Farms in the southeast, especially the larger farms with land along creeks or river bottoms, grew some corn as a feed grain.

Although the acres of land devoted to different uses varied widely among individual farms, little variation among the groups was found in the percentage of total farmland devoted to a given use. Native grass and woodland pasture represented the greatest utilization of land. All but three farms were producing grain or forage crops that were complementary to the dairy enterprise. Generally, complementary crops were fed on the farm and marketed through the sale of milk.

Livestock

The average number of dairy cattle per farm was 68.7 animals and ranged from 28 to 204 animals (Table III). Groups A and B reported approximately equal size herds of 40.5 and 42.4 animals respectively. Farms in group C reported 68.0 dairy animals per farm and farms in group D averaged 80.4 dairy animals. In group E, the average number reported per farm was 112.3 animals and ranged from 52 to 204 head.

Evidence of the relatively high degree of specialization of dairy farms with bulk milk tanks is indicated by the inventory of other livestock on farms (Table III). Generally, the survey farms reporting livestock other than dairy indicated production primarily for home use.

About 10 percent of the sample farms reported a beef enterprise. The average number of animals on these farms was 95.2 head. There were no beef animals reported on farms in the two largest size groups. Beef animals appeared to be the only livestock enterprise, other than dairying, of any commercial consequence on these farms. In addition to the beef-type animals reported, it appeared to be common practice on these farms to sell dairy bull calves as beef or vealers. This is consistent with Blakley's findings that beef cattle are the best alternative for some farms producing Grade A milk in the Oklahoma City milkshed.[2]

Ten farms reported hogs, five growing hogs commercially and five for home consumption. Seven of the farms reporting hogs, were farms producing less than 15,000 pounds of milk per month. No farms in the two largest milk producing groups reported a commercial hog enterprise.

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[2]Leo V. Blakley, p. 3.

Table III

Number of Animals of Each Livestock Class and Number of Animal Units on Farms in Sample, Oklahoma City Milkshed, 1957[a]

	Total		Group A 0-10,000 lbs.		Group B 10-15,000 lbs.		Group C 15-20,000 lbs.		Group D 20-30,000 lbs.		Group E ≥ 30,000 lbs.	
	Farms Reporting	Avg. No.	Farms Reporting	Avg. No.	Farms Reporting	Avg. No.	Farms Reporting	Avg. No.	Farms Reporting	Avg. No.	Farms Reporting	Avg. No.
Number of Animals per Farm	50	624.2	10	99.1	10	110.6	10	178.1	10	97.6	10	2635.6
Dairy	50	67.5	10	40.5	10	42.4	10	68.0	10	80.4	10	106.4
Beef	5	95.2	1	31.0	1	12.0	3	144.3	0	0	0	0
Hogs	10	22.8	4	21.2	3	17.6	1	87.0	1	1	1	2
Poultry	29	932.0	5	94.0	6	102.8	8	72.6	4	42.7	6	4215.0
Number of Animal Units per Farm[e]	50	64.4[d]	10	33.2	10	33.4	10	83.6[b]	10	58.8	10	113.0[c]

[a]Averages in all cases are computed on the basis of number of farms reporting.

[b]Average would be 54.2 if C-1 is omitted containing 332 beef cattle.

[c]Average would be 79.3 if E-3 is omitted containing 25,000 laying hens.

[d]Average would be 51.2 if C-1 and E-3 are omitted.

[e]Animal units based on the relative amounts of feed consumed by different classes of livestock. G. W. Forster, Farm Organization and Management (New York, 1953), p. 401.

Poultry was produced on 29 of the sample farms, but only five farmers reported 200 or more birds per farm. Only one farm reported a poultry enterprise large enough to be important commercially.

Because of the variability in numbers and types of livestock, a comparison of the total number of livestock reported at different levels of milk production was made on the basis of a feed consuming animal unit.[3] On this basis the animal units averaged 66.4 per farm. Generally, the number per farm increased as the level of milk production increased, reflecting the large number of dairy animals found on these farms.

Dairy Herd Composition

The average number of dairy cows on sample farms was 37 head (Table IV). This ranged from eight to 142 cows per farm.[4] The average production per cow in 1957 was estimated at 6,913 pounds per year.[5] In a study in this same area, Blakley estimated an average production per cow for

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[3] G. W. Forster, Farm Organization and Management, (New York, 1953) p. 401. Each type and class of livestock reported by farmers was reduced to a common base by defining one steer, one cow, two heifers, four calves less than 12 months old, three sows, five mature hogs, ten pigs of 100 pounds each, and 100 hens to be the equivalent of one animal unit.

[4] This and all subsequent references to dairy cows refers to cows, dry and milking, two years of age and older.

[5] The average production per cow in each strata is a simple average based on sales of milk in 1957 and the number of dairy cows on farms. The average for the total sample is a weighted average where the average for each group is weighted by the percentage that the possible sampling units in each group is of all possible sampling units, (page 8).

Table IV

Herd Composition and Average Number of Dairy Cattle per Farm in Sample, Oklahoma City Milkshed, 1957[a]

Item	Total		Group A 0-10,000 lbs.		Group B 10-15,000 lbs.		Group C 15-20,000 lbs.		Group D 20-30,000 lbs.		Group E > 30,000 lbs.	
	Number Reporting	Ave. No.	Number Reporting	Ave. No.	Number Reporting	Ave. No.	Number Reporting	Ave. No.	Number Reporting	Ave. No.	Number Reporting	Ave. No.
Total Per Farm	50	67.5	10	40.5	10	42.4	10	68.0	10	80.4	10	106.4
Cows (dry and milking)	50	37.0	10	18.7	10	22.4	10	32.3	10	41.8	10	69.9
Heifers 1-2 years	48	15.8	10	8.8	10	8.7	9	19.2	10	21.3	9	21.8
Heifers under 1 year	48	12.2	10	7.6	10	8.2	10	11.5	9	15.1	9	19.8
Bulls	46	1.7	10	1.4	7	1.1	9	2.0	10	1.7	10	2.2
Others	24	6.7	5	8.0	6	3.8	5	10.2	4	5.0	4	7.0
Raised in 1957	49	15.0	10	9.0	10	10.1	10	16.0	9	18.0	10	22.2
Deaths in 1957	33	3.6	3	1.7	8	2.0	5	3.6	7	3.6	10	5.6
Bought in 1957	23	8.1	4	3.5	6	6.3	2	5.2	6	7.3	5	15.0
Sales in 1957	47	11.5	9	7.3	10	5.2	10	11.3	10	17.6	8	17.0

[a]Averages in all cases are computed on the basis of number of farms reporting.

all Grade A producers of approximately 5,610 pounds in 1950.[6] Underwood reported an average of 5,470 pounds per cow for 1950.[7] Inflating these figures by 21.86 percent, the resulting production figures would be 6,836 and 6,666 pounds per cow respectively.[8] These estimates suggest that production per cow on bulk tank dairy farms is not significantly different than for all Grade A producers in this area.

The average number of dairy cows per herd was directly associated with milk sales. Farms in group A reported 18.7 dairy cows per farm. These farms accounted for only 10.3 percent of all cows in the survey, but 100 percent of the cows for this group. Production per cow averaged 5,370 pounds per year. This was considerably below the average for all bulk producers and the lowest for any group.

Farmers in group B reported an average of 22.4 dairy cows per farm. Farms of this size accounted for 12.1 percent of the dairy cows in the survey and 22.3 percent of the total number of all farms. The average production per cow was 6,971 pounds per year.

Producers in group C reported 32.3 cows per farm. Farms in this group accounted for 17.4 percent of the cows in the survey and 29.4 percent of the 210 farms eligible to be included in the study. The average production per cow on farms in this group was 6,658 pounds per year.

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[6]Leo V. Blakley, p. 7.

[7]F. L. Underwood, p. 7.

[8]The expansion factor of 21.86 percent was computed from the average production for all producers of 3,660 pounds of milk in 1950 and 4,460 pounds in 1957. See United States Department of Agriculture, Milk Production on Farms and Statistics of Dairy Plant Production, 1957, (Washington, D. C., February, 1958 and previous issues).

Farms in group D reported 22.5 percent of the dairy cows in the survey and 30.8 percent of the possible sample farms. Farms with this level of production averaged 41.8 dairy cows. The average production per cow was 7,150 pounds.

Farms in the largest size group reported an average of 69.9 dairy cows. Because of the wide limits allowed in this strata, these farms reported a range of 40 to 142 cows. This group, while containing only 12.8 percent of the farms in the study, accounted for 37.7 percent of the dairy cows. The average production per cow was 7,399 pounds per year. This was the highest average per cow for all the groups.

All farms contacted were raising their own herd replacements. The average number of heifers under two years old was 28 head (Table IV). This represents 75.7 percent of the number of cows of milking age on these farms. If a heifer-cow ratio of 50 percent is required to maintain herd size, this figure may indicate a planned expansion of milk production on these farms. However, the increased ratio may also reflect farmers' realizations that some of these heifers may not be suitable for herd replacements.

The ratio of heifers to dairy cows was greatest on farms in group C. The 30.7 heifers reported on these farms was 95.0 percent of the number of dairy cows reported. The 41.6 heifers per farm in group E represented 59.5 percent of the average number of cows reported on these farms, the smallest percentage reported. For the remaining groups, the replacement percentage ranged from 75.4 to 87.7 percent.

All but four respondents reported a herd bull on the farm. The average number of these animals was 1.7 per farm. Two farmers reported cows being bred by artifical insemination. Several other farmers had attempted this method of breeding cows in the past but reported that results had not been satisfactory.

Available Labor

Farm enterprises may be classified as labor intensive or labor extensive. Labor extensive enterprises are those which require relatively small amounts of labor per unit of output, and labor intensive enterprises are those which require relatively large amounts of labor per unit of output. Dairying is considered to be a labor intensive enterprise. In a study of 140 dairy farms within the Oklahoma City milkshed, Underwood found an average labor requirement per cow of 124 hours per year.[9]

Mechanical innovations represented by the milking machine, bulk tank, pipeline milkers, and parlor barn may be reducing these labor requirements. Many studies have pointed out that by converting to bulk milk handling, the quantity of labor is not necessarily reduced but labor may be saved qualitatively. With a bulk tank system, chores such as lifting cans of milk and handling and washing milk cans are eliminated. This has a twofold advantage in that the family is able to do more of the milking chores, the operator is released for other jobs, and hired labor is easier to obtain and keep. However, in addition to making the job easier, all but two farmers in this study reported some saving in clean-up time after milking.

Labor used on farms with bulk milk tanks in the Oklahoma City area is fairly homogeneous in composition. Family labor is used primarily

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[9] F. L. Underwood, p. 19.

on all farms averaging less than 30,000 pounds of milk per month. This source accounted for all labor used in the milking operation on 76 percent of the sample farms. Of the 12 farms hiring labor for this purpose, eight were in the group averaging greater than 30,000 pounds of milk per month. Hired labor was used in the milking operation on one farm in group A and on one farm in group C. In both instances the operator and his wife had full time off-farm jobs. Two farms in group D reported hired labor used to assist the operator in the milking operation.

The average age of the dairy operator on farms with bulk milk tanks was 46.1 years. The average age of the operator in each of the size groups did not differ greatly from this average. However, five farmers in both groups A and E were above 50 years of age.

Buildings and Facilities

The milkhouse on most dairy farms in the sample represented an investment of approximately $2,500. Concrete blocks were the most common building material used (Table V). This material was used frequently by the smaller producers. Seven farmers reported using a wooden milkhouse, either an older building or a combination feed barn and milkroom. Milkhouses classed as "other" included frame buildings with a metal covering, tile block, and brick. These were used primarily by large volume producers. Generally, these farmers had been producing milk commercially for relatively longer periods of time than other producers in the sample.

Wooden walk-in stalls were reported in use on 31 of the 50 sample farms. No significant difference existed between the groups. Metal walk-in stalls were used on seven farms. The parlor type milking barn

Table V

Dairy Equipment and Type of Milkshouse Construction on Farms in Sample, Oklahoma City Milkshed, 1957

Number of Farms Having	Total	Group A 0-10,000 pounds	Group B 10-15,000 pounds	Group C 15-20,000 pounds	Group D 20-30,000 pounds	Group E > 30,000 pounds
Milkhouse Construction						
Concrete block	32	9	7	8	4	4
Wood	7	1	1	2	1	2
Other	11	0	2	0	5	4
Stalls						
Wood	31	6	7	7	7	4
Metal	7	2	2	1	0	2
Average number[a]	7	5.4	6	5.7	7.4	10.4
Parlor	12	2	1	2	3	4
Electric Milkers	50	10	10	10	10	10
Pipeline Milkers	17	1	2	2	6	6
Hot Water Heaters						
Electric	5	0	1	1	2	1
Gas	45	10	9	9	8	9
Average size[a]	31 gal.	27 gal.	27 gal.	31 gal.	32 gal.	40 gal.
Bulk Tanks	50	10	10	10	10	10
Average size	353 gal.	233 gal.	244 gal.	332 gal.	339 gal.	582 gal.

[a]Averages in all cases are computed on the basis of number of farms reporting.

was used by 12 producers. The parlor type milking arrangement contributes to a qualitative and a quantitative saving of labor. The savings in labor are greatest when used with a pipeline milker. There was a tendency for the parlor-type barn to be associated with large volume production.

Dairymen on all farms were using electric milkers. Seven farms installed electric milkers at the time of conversion or soon afterwards; all others were using electric milking equipment before purchasing a bulk tank. In contrast, Underwood found only about two out of every five dairymen in the same area in 1950 were using milking machines.[10] The number of farms using milking machines in his study varied considerably among different geographical sections of the market. In general, milking machines were more prevalent in the eastern part of the area.

There was little difference between groups in the number of milker units used per farm except for the largest group which reported 3.8 units per farm. (Milker units refer to the number of cows that may be milked at a given time with one milking machine.) Farms in the other groups averaged 2 units in group A to 2.7 units in group D.

Pipeline milkers are being adopted rapidly by Oklahoma dairy farmers. The pipeline milking arrangement is essentially a labor saving device and, on farms where labor is the scarce resource, it can be used profitably. However, it represents a large capital investment, ranging from

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[10] Ibid., p. 18. It should be noted that Underwood's study was based on a sample of all Grade A producers and that bulk tanks were not then in use. The present study is more restrictive in that only a restricted population of bulk producers were sampled and these were relatively long-time producers.

$1,100 to $2,200 depending on the amount of stainless steel or plastic pipe needed. With this arrangement one man (or woman) can perform the entire milking operation on an average farm.

Seventeen of the sample farms reported using pipeline milkers. The number of farms using this equipment appears to be closely correlated with volume of production. Of the 17 farms reporting pipeline milkers in use, 12 were in the two groups averaging more than 20,000 pounds of milk per month. The accelerated installation rate of pipeline milkers is consistent with the trend toward greater farm automation.

Hot water heaters are required in the milkroom by the State Health Department. Farms with a 500 gallon or smaller, bulk milk tank are required to have a 30 gallon gas or 40 gallon electric water heater. For tanks larger than 500 gallons, a 10 gallon increase in size of water heater per 100 gallon increase in size of bulk tank is required. All 50 of the survey farms were using hot water heaters, 45 using gas as a fuel and 5 electricity. All farms, however, did not have a tank of prescribed capacity. The average capacity per farm was 31 gallons. There was a slight increase in size of water heater as milk production on farms increased. This item is likely to represent a substantial addition to conversion costs for most producers, since 28 of the 50 bulk tank producers indicated installation of a water heater at the time of conversion.

Size of Bulk Tanks

The average size bulk tank used on the sample farms was 351 gallons. The range was from 145 to 1,000 gallons. The average size bulk tank used on farms in group A was 233 gallons with no tanks reported larger than

300 gallons. The average size tank in use on farms in group B was 244 gallons with 400 gallons the largest reported. The average reported for groups C and D was 355 and 399 gallons respectively. There were no farms in group E using a bulk tank less than 485 gallons in size. The average size tank reported for this group was 582 gallons. The number of tanks ranging from 200-300 gallons accounted for 50 percent of the tanks in the survey.

The average amount of milk cooled per pick-up may influence the level of costs associated with operating a bulk tank. Pick-up receipts were not readily available for an estimate of the actual tank utilization. In the absence of such data, producers were asked to estimate an average percent of utilization per pick-up for the year 1957. These estimates ranged from 30 to 80 percent with an average utilization per pick-up of 60 percent of capacity. Group A producers reported only 55 percent average usage per pick-up. This usage factor increased directly with level of milk production. Farmers in group E reported an average of 65 percent of tank capacity per pick-up during the year.

Problems Associated with Bulk Milk Tanks and Producer Attitudes

Farmers in the survey were asked to indicate their experiences with problems associated with bulk milk handling. These problems were: (1) milk rejected, (2) churning of the milk, (3) freezing of the milk, and (4) off-flavors and odors in the milk.

When milk is cooled in a bulk tank, there is the ever-present danger that milk from one cow may cause the entire tank of milk to be rejected.

Respondents in this study indicated only two tanks of milk had been rejected for this reason. Both instances occurred on farms in group A.

A second problem, churning of the milk in the tank, occurred on seven of the survey farms. When this happens, all of the milk in the tank may be lost or in some cases it may be sold at a reduced price. The churning problem usually occurred when the agitator was left running while the compressor was not operating.

In some types of bulk tanks the milk may freeze. This problem was reported on 11 of the survey farms. Freezing was most prevalent when only a small amount of milk from the first night's milking was in the tank. Freezing may also occur if the agitator is not operating when the compressor is running.

The last major problem cannot be attributed exclusively to the bulk milk tank, since it may occur as easily with a can handling system. Trouble with milk odors was reported on 16 of the 50 sample farms. Most respondents indicated the odors occurred in the spring when cows were grazing on wheat or oat pasture and had not been removed from the pasture a sufficient length of time prior to milking.

Trouble normally associated with milk appears to occur less frequently with bulk tanks than with can coolers. Of the 50 producers interviewed, all were satisfied with the new method and none would consider reverting to a can handling system. Thirty-seven of the 50 producers indicated they were happy with the weight and test of milk received since converting. In reply to the question, "Do you think the market will eventually be all bulk milk?", 47 of these producers replied in the affirmative. The two most frequent reasons given were: (1) a better quality product for consumers, and (2) the Health Department will require it.

Changes in Production After Installing Bulk Milk Tanks

The use of a bulk milk tank on dairy farms may induce changes in farm organization and size of operation. To ascertain the type and magnitude of these changes, farmers were asked to indicate the adjustments that had taken place on their farms since the installation of the bulk milk tank. Some of these changes were directly associated with the use of the bulk tank, others were not.

The most significant change was the increase in number of dairy cows. Sixty percent of the farmers in the survey reported a change in the number of dairy cows on farms since the acquisition of a bulk tank. Two farmers had reduced the number of dairy cows, but 28 farmers reported an increase in the number of dairy cows on farms (Table VI). The average increase was 6.2 dairy cows per farm. There was no appreciable difference between groups in the number of farmers reporting increases; however, the average increase per farm was greatest in the two groups with the highest average monthly production of milk.

A second change, closely associated with the increased number of dairy cows, was the increase in milk production per farm. This increased output is accounted for by increased numbers of cows on farms and the addition of higher producing cows.

A trend in milk production per farm for the two-year period August, 1956, to July, 1958, was computed by least squares. The prediction equation for all sample farms was $\hat{Y} = 210.0142 + \underset{(.4639)}{.38549}X$.

Where $\hat{Y}$ = hundredweight of milk sold per month

X = number of months since August, 1956.

Table VI

Number of Farms in Sample Reporting Changes in Herd Size and Farm Size After Installation of a Bulk Tank, Oklahoma City Milkshed, 1957

No. of Farms With	Total	Group A 0-10,000 pounds	Group B 10-15,000 pounds	Group C 15-20,000 pounds	Group D 20-30,000 pounds	Group E > 30,000 pounds
Decreased milking herd	2	1	0	0	0	1
Increased milking herd	28	4	6	4	8	6
Smaller farm size	5	2	0	0	1	2
Larger farm size	5	1	0	2	0	2

Table VII

Specific Changes Planned by Producers in Sample, Oklahoma City Milkshed, 1957

Specific Plans	Total	Group A 0-10,000 pounds	Group B 10-15,000 pounds	Group C 15-20,000 pounds	Group D 20-30,000 pounds	Group E > 30,000 pounds
				(Number)		
Expand number of cows	35	8	8	6	9	4
Average increase in cows per farm[a]	17.2	15.2	13.7	25.0	20.7	15
Install a pipeline milker	15	3	4	4	2	2
Buy a larger bulk tank	8	0	2	2	4	0

[a]The average is computed on basis of number of farms reporting.

The estimated average increase on the sample farms for this time period was 38.549 pounds of milk per month. This trend in milk sales is consistent with farmers' estimates of increased numbers of cows on these farms and is illustrated in Figure 4. A seasonal pattern is also evident with the greatest production in the spring months and the lowest production in the late summer months.

Milk production per farm did not increase for producers in all size groups. Increases in the number of dairy cows per farm were reported by only four producers in group A. The trend in the average milk sales per farm for producers in this group has been decreasing at the rate of 61 pounds per month (Appendix Table IV).

Survey farms in group B have been increasing milk production at the rate of 118.55 pounds per month (Appendix Table IV). Since installing a bulk milk tank, six of the 10 farms in this group have increased the number of dairy cows an average of 3.3 cows per farm.

Farms in group C have experienced the largest increase in production per month, 135.541 pounds (Appendix Table IV). Since installing a bulk milk tank, four farmers in this group have increased the number of dairy cows an average of 5.3 cows per farm.

The upward trend in milk production per farm in group D was 45 pounds of milk per month (Appendix Table IV). Eight farms in this strata reported an average increase of 9.2 dairy cows per farm.

The estimated trend in milk production on farms in group E indicates a decrease in production of 45.709 pounds of milk per month (Appendix Table IV). However, six farmers in this group reported an increase of 7.5 dairy cows per farm since installing a bulk tank.

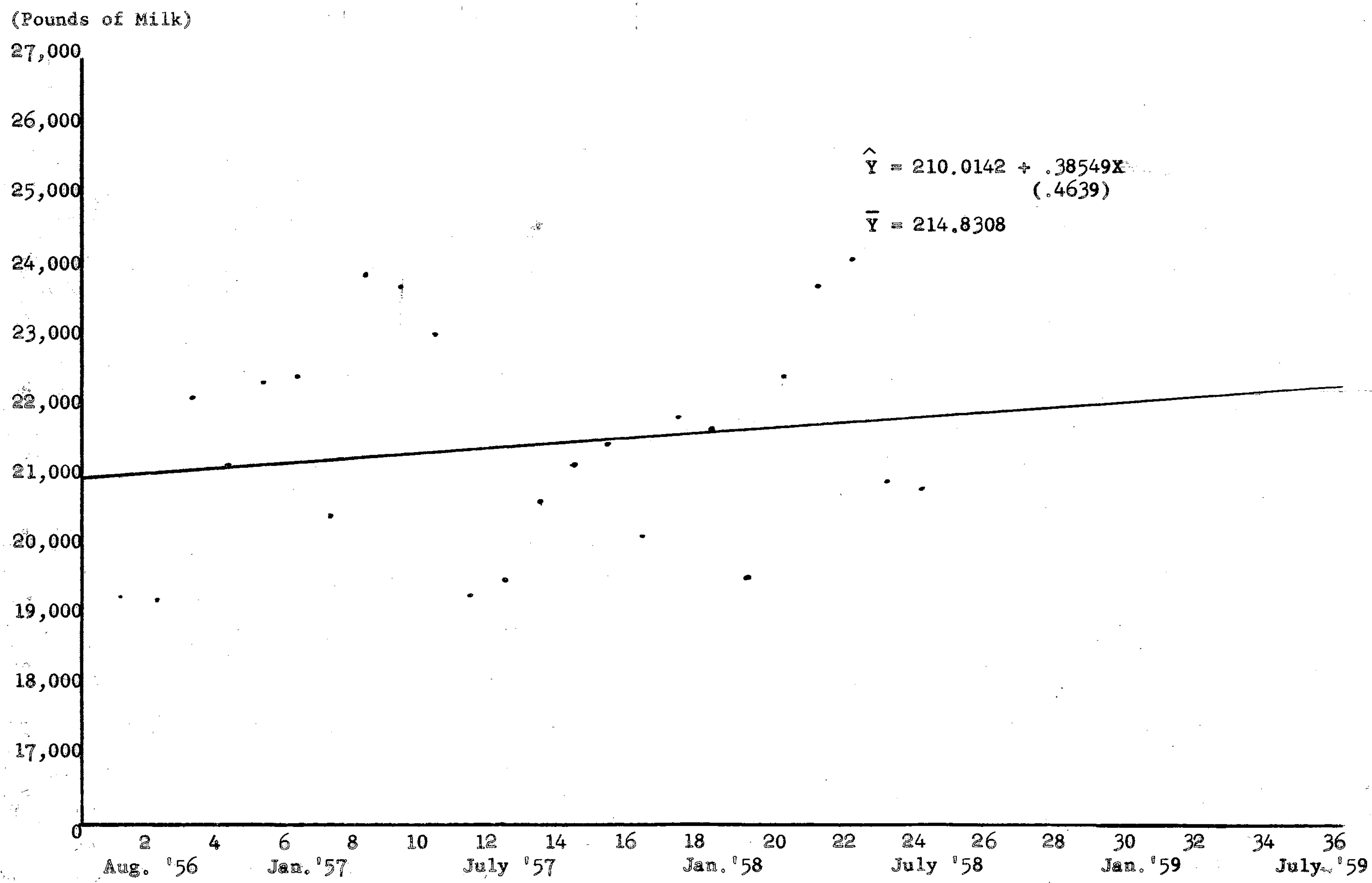

Figure IV. Trend in Milk Sales from Farms in Sample, Oklahoma City Milkshed, August, 1956 to July, 1958

In order to add more cows and increase production, it is frequently necessary to add more land area. Information from the survey indicated that 22 farmers, 44 percent of those interviewed, had added farm land since installing a bulk milk tank. For these 22 farms, the average addition was 153.2 acres.

If the survey farms in this study are representative of all bulk producers, dairymen with bulk tanks in the Oklahoma City milkshed have been increasing the number of dairy cows on farms and the volume of milk per farm. This trend may be expected to continue over the next five year period. About 70 percent of the farmers plan to add an average of 17.2 dairy cows per farm during this period (Table VII). However, there is great variation between the size groups and between farms within each group.

There are indications that farms averaging less than 10,000 pounds of milk per month are decreasing output. Some farmers in this group appear to be adjusting to some alternative farm enterprise or obtaining non-farm employment, while others are increasing the size of the milking herd and moving to a higher level of production. Most farmers in the production range of 10,000 to 30,000 pounds per month are increasing their scale of operation. This may permit these farmers to take advantage of lower fixed cost per unit and increase net revenue from the dairy enterprise. This group would include 82.4 percent of the 210 producers defined to be eligible for the survey. Most farms averaging greater than 30,000 pounds of milk per month are expected to continue their operation with the present number of cows. Many of the farmers in this group reported they were content to increase output per farm by attempting to increase production per cow.

New equipment purchases are contemplated by many farmers within the next five years. Thirty percent of the producers expect to install a pipeline milker and 16 percent expect to buy a larger bulk tank.

CHAPTER V

COSTS OF INSTALLING AND OPERATING BULK MILK TANKS ON OKLAHOMA DAIRY FARMS

In considering conversion to a bulk milk system, dairymen are interested in two groups of price and cost data. The first group is associated with the initial investment outlay likely to be required when converting to the bulk tank system. The second group is concerned with the cost of cooling a given amount of milk. Any premiums or savings accruing from the conversion will also be of interest to dairymen since they may offset part or all of these added costs.

Bulk tank manufacturers and other firms actively engaged in selling and installing bulk tanks provided information related to the initial cost of installing tanks of various sizes. Farmers contributed information regarding necessary modification costs of dairy plant and equipment. Detailed cost data for both of these groups were necessary in order to provide reliable estimates of costs for various levels of milk production. Farmers also provided estimates of the additional returns associated with the use of a bulk milk tank.

Initial Conversion Cost

The initial investment required to convert to bulk milk handling is the cost of the tank installed on the farm plus any necessary costs of modifying existing facilities. Results of this study indicated that the tank cost varied primarily in proportion to its size, but the expense of changing existing facilities varied widely from farm to farm. These latter costs were associated with: (1) construction of or additions to buildings, (2) installation of heavier electrical wiring, (3) purchase of hot water heaters, and (4) improvements of farm roads and lanes.

Tank Costs

Variations in prices of bulk tanks of a similar size may be due to differences in make, type of cooling, type of finish, tank design and method of sealing the lid, and dealer discounts. These factors were considered in attempting to establish costs of installing a bulk tank.

From the records of Central Oklahoma Milk Producers Association, it was found that four makes, Sunset, Blackburn, Zero, and Creamery Package, comprised 88.9 percent of the tanks used in the Oklahoma City milkshed. The remaining 11.1 percent was composed of nine different makes.

Price lists for 1958 for the four major brands were obtained with the various components of total installed price listed separately. In each case, a list price and a discounted price was given. The discounted prices were used since they coincided with those on the producers' loan records.

Prices for the four principal makes of tanks were averaged for each of 10 different size classifications and the results are shown in Appendix Table I. The average installed price is assumed to be representative of all makes of tanks. In computing this average however, consideration has been given to price variations of tank components between makes of tanks. Considerable variations in items listed as tank components by different tank manufacturers may also be reflected in tank price quotations. Some manufacturers list the compressor separately and some include it with tank cost. Others, Creamery Package for example, list several pieces of their equipment separately. These differences between makes of bulk tanks were given careful consideration when determining the total installed price.

Table VIII indicates price and cost data for 10 different sizes of bulk tanks. The average cost per gallon and per hundredweight, assuming 100 percent capacity utilization for each size, decreases as size of tank increases. These decreasing cost relationships would hold for any given percent of capacity utilization. The use of 1958 prices may overstate the actual costs of the farms in this study but it does provide an up-to-date estimate of conversion costs which a producer at these various levels would be facing if he were currently contemplating conversion.

The average size of the bulk tank in each size group together with the cost data in Table VIII was used to determine the typical outlay for the sample farms. By this method, the average producer in the sample had a tank size of 351 gallons costing $2,410.66 (Table IX). The range in tank cost was $1,963.48 for farms in group A to $3,247.75 for those in group E.

Costs of Improving and Modifying Buildings and Facilities

Many producers have incurred additional plant and equipment costs (other than the bulk tank) when converting to a bulk handling system. Farms that require these items before conversion and would not require them with a can system, must consider these costs as part of the total conversion outlay.

Milkhouse Improvements. There is little difference between a bulk system and a can system in terms of milkhouse requirements, but in some

Table VIII

Average Prices and Costs for Ten Sizes of Bulk Tanks Available in the Oklahoma City Milkshed, 1957[a]

Size of Tank		Cost to Farmers		Average Cost	Average Cost
Gallons	Pounds	Average Price	Range in Price[b]	Per Gallon	Per Cwt.
100	860	$1,437.21	$1270-1604	14.37	167.12
150	1290	1,734.47	1660-1840	11.56	134.45
200	1720	1,924.61	1742-2006	9.62	111.90
250	2150	2,042.04	1944-2110	8.17	94.98
300	2580	2,279.09	2182-2351	7.60	88.34
400	3440	2,610.50	2541-2645	6.53	75.89
500	4300	2,991.91	2886-3289	5.98	69.60
600	5160	3,396.76	3194-3790	5.66	65.83
800	6880	4,226.05	3734-4785	5.28	61.42
1000	8600	4,458.99	4232-4793	4.46	51.85

[a]The discounted prices of the four brand name tanks were used in making these computations. These were Sunset, Blackburn, Zero and Creamery Package.

[b]Range in price refers to the prices of the four makes of tanks used in computing the average price.

Table IX

Estimated 1957 Tank Cost and Cost of Improvements per Farm
in Sample, Oklahoma City Milkshed, 1957

Item	Total	Group A 0-10,000	Group B 10-15,000	Group C 15-20,000	Group D 20-30,000	Group E > 30,000
Tank:						
Average size (gallons)	351	233	244	355	339	582
Average cost per farm	$2,410.66	1,963.48	2,037.25	2,413.01	2,391.80	3,247.75
Improvements:						
Milkhouse:						
New construction:						
Farms reporting	5	1	1	0	2	1
Costs per farm[b]	2,500.00	2,000.00	2,500.00	-[a]	2,750.00	2,500.00
Remodeled:						
Farms reporting	19	5	2	4	4	4
Costs per farm[b]	$ 29.82	9.20	15.00	22.70	10.00	100.00[a]
Electric Wiring:						
Farms reporting	27	7	7	7	1	5
Costs per farm[b]	$ 29.62[a]	24.00	24.50[a]	34.10[a]	15.00	44.80[a]
Purchase of Water Heaters:						
Farms reporting	28	6	3	4	8	7
Costs per farm[b]	$ 83.00[a]	79.67[a]	94.50[a]	-[a]	71.00[a]	86.60[a]
Improvements of Roads and Lanes:						
Farms reporting	19	4	5	2	3	5
Costs per farm[b]	$ 30.69[a]	27.00[a]	30.00[a]	-[a]	36.00	30.00[a]
Average of all Improvement Costs Per Farm[b]	$ 37.65	28.59	38.00	26.91	30.50	60.27

[a]Data not available on all farms.

[b]Average computed on basis of number of farms reporting that could provide cost data.

cases additional expense may be expected. Five producers constructed a new milkhouse and 19 remodeled the old milkhouse before installing the bulk tank (Table IX). Remodeling in most cases consisted of rearranging or adding to the plumbing, adding a cement slab to facilitate loading, and removing or adding a partition.

For the five farms reporting construction of a new milkhouse, the average cost was $2500 per farm. This was not included in computing the average cost per farm for milkhouse improvements. On all five farms reporting, the installation of a bulk tank in itself did not require the building of a new milkhouse.

Excluding the new milkhouse figures, the estimates for milkhouse improvements averaged $29.82 for the 19 farms reporting expenses of this type. These costs ranged from $0.00 to $200.00 per farm. In most cases the costs reported were for materials only. Where farm labor was used, no addition to cost was reported.

Electric Wiring. Electrical wiring in dairy barns in this area is often inadequate to carry the load of the large compressors required for bulk milk tanks. This is especially true if the tank is of the direct expansion type.

Twenty-seven farms reported they had incurred an expense of this type. The average cost of wiring for these farms was $29.62 with a range in cost of $0.00 to $100.00 per farm. This relatively small figure reflects the use of farm labor in many instances. On 76 percent of the farms, the cost came as a result of changing from a 110 to a 220 volt system. Generally, there were fewer farms in the larger size groups reporting this added expense. Presumably, the larger volume producers had made this change because of the size of their can operation prior to converting to a bulk tank.

Hot Water Heaters. Health department regulations require dairymen who use a bulk tank to include a pressurized hot water heater as part of their milk room equipment. Many dairy farmers in Oklahoma not using bulk tank systems have open vat arrangements to heat water. For these farms the cost of a hot water heater is a necessary part of the conversion cost. On some farms the installation of a bulk milk tank may require a larger water heater than is currently in use to meet health department specifications. In either of these two cases the added expense of the water heater should be charged to the new system.

About half the farmers incurred additional expense for a hot water heater. Contrary to expectations, the number of farms requiring this expense increased with size of farm. Three-fourths of the producers averaging greater than 20,000 pounds of milk per month reported some outlay on a hot water heater. About 40 percent of these found it necessary to purchase a larger water heater than the one currently in use.

Determination of the average cost per farm for this item was based on limited information. Only 10 of the 28 farmers reporting purchase of a water heater could provide estimates of the cost. For these 10 farms the average expense was $83.00 for this item. In several instances, the heater was installed with farm labor.

Improvements of Farm Roads and Lanes. Farmers with bulk milk tanks may be required to make some road (driveway) improvements in order to have their milk picked up by the hauling agency. With a can system the cans of milk may be picked up at the milkhouse or transported by the farmer to the roadway during inclement weather. However, with a bulk system the tank truck must go to the milkhouse each time milk is picked up.

Farm driveways or lanes in the Oklahoma City area are usually dirt roads, and often become almost impassable when wet. In a cost study in this milkshed, Blakley estimated a total cost of 42.6 cents per mile to the Association for year-round travel on poor dirt roads.[1] In that study, the advisability of adding a producer was questioned when that addition required travel on poor dirt roads on or off the farmstead. If the Central Oklahoma Milk Producers Association should require bulk producers to have all-weather roads and lanes before their milk can be picked up, this improvement cost would become an integral portion of the conversion costs. If this is not done the hauling rate to all producers would necessarily be high enough to cover the added costs of travel on these road types. Thus far, the Association has not forced producers to make improvements but it has made suggestions and provided financing and cost sharing arrangements for improvements of this type.

Only 19 producers reported improvement expense on roads and lanes since installation of the tank. The average annual expense was $30.69 per year and, with one exception, reflects the use of farm labor and machinery. These figures do not include farms that occasionally hauled dirt or other material either before or after conversion. While there were no great differences in the average cost per farm at different

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[1] Leo V. Blakley, Walter B. Rogers, and Kenneth B. Boggs, A Preliminary Report on an Analysis of Bulk Milk Transportation Costs of the Central Oklahoma Milk Producers Association, (Oklahoma State University, 1958), p. 15.

levels of milk production, there was a difference between farms in the eastern half and farms in the western half of the milkshed. Because of a clay soil and a rolling terrain, as contrasted to a more level sandy soil, more farms in the East incurred this expense and at a generally higher cost per farm than in the West.

Salvage Value of Can Equipment and Financing Arrangements

Producers in the Oklahoma City area generally have been successful in disposing of their used can equipment. On most farms the amount received for cans and coolers was large enough to make the down payment required on the bulk tank. The unpaid balance was financed through some agency by 90 percent of the farmers. Information was obtained from these farmers regarding the amount received for their can equipment and the cost and sources of credit used in financing the conversion to a bulk system.

Salvage Value of Can Equipment. Eighty-two percent of the producers were able to dispose of their milk cans and coolers. Nine of these producers sold their coolers to other farmers while 33 producers traded the can equipment in on the bulk tank.

The average value received per farm from disposal of cans and coolers was $208.29 (Table X). The 41 farms disposing of cans reported an average of 12.6 cans sold with an average value received of $36.50 per farm. The 44 farms that sold and traded their can coolers reported a value received of $171.79 per farm. The range in salvage value received per farm was $156.50 for farms in group A to $279.47 for those in group E. Generally, farms with a larger volume of milk usually had a larger capacity cooler

Table X

Disposition Value of Used Can Equipment on Farms in Sample, Oklahoma City Milkshed, 1957

Item	Total	Group A 0-10,000	Group B 10-15,000	Group C 15-20,000	Group D 20-30,000	Group E > 30,000
Cans						
Farms reporting	41	9	9	7	8	8
Number per farm	12.6	12.0	7.5[a]	13.1	15.1[a]	20.5
Value received per farm	36.50	34.00[a]	26.75[a]	48.99[a]	44.17[a]	70.19
Can Coolers						
Farms reporting	44	9	9	10	9	7
Can capacity	8.2	6.5	7.1	7.9	9.8	9.7
Value received per farm	171.79	122.50[a]	152.77	154.90	225.14[a]	209.28
Average Total Value Received per Farm	208.29	156.50	179.52	203.89	269.31	279.47

[a]Data not available on all farms reporting. The average is computed on the basis of number of farms for which data were available.

and more cans, consequently the salvage value received per farm was greater.

Disposition of used can equipment for an amount sufficient to make the required down payment on the bulk tank has tended to reduce the financial barrier associated with tank ownership. Although there has been a ready market for these coolers and cans, the demand may be expected to decrease as the shift to bulk handling continues. Farmers converting in the future may not be able to salvage their present equipment with the degree of economic advantage that has been experienced in the past.

Financing Arrangements: Sources and Costs. The large initial outlay required to purchase a bulk tank represents the major conversion problem to many can producers. This problem is enhanced by the requirement for improvements in existing facilities. In order to be within the reach of most farmers, there must be some system of financing the conversion.

Several sources of credit are open to producers. The most frequently used arrangement, however, is that afforded by Central Oklahoma Milk Producers Association. In this arrangement, the Association purchases the tanks in quantity lots for resale at less-than-retail prices to their members. It disposes of the producers' old can equipment, installs tanks, calibrates, services tanks, arranges financing, and deducts repayments from producers' monthly milk checks.

The Association financed all but one of the 45 producers who obtained a loan to purchase a bulk tank. This one loan was financed through the Rural Electric Cooperative. Apparently the latter source has not been exploited since the interest rate is very low and monthly payments may be added to the electric bill for convenience of payment. Production Credit Associations were expected to be one of the more active lenders for this purpose; however, records of the Federal Intermediate Credit Bank at Wichita, Kansas, reveal only one loan discounted in the state of Oklahoma for this purpose. It is possible that more loans by local production credit associations have been made through regular operating funds. Other lending agencies include local banks and bulk tank distributors but evidently these are not frequently used.

Three credit institutions available to farmers were contacted regarding the cost of financing bulk milk tanks. The Central Oklahoma Milk Producers Association charges 5.7 percent of the unpaid balance per year. The unpaid balance is equal to the cash price of the tank installed minus ten percent down payment plus cancellation insurance. Cancellation insurance for the three-year period is 2.26 percent of the cash price installed minus the down payment. In calculating the finance cost, charges of 11 percent of the unpaid balance are used for a three-year finance period.

The Central Rural Electric Cooperative charges a rate of 3.7 percent annually on the unpaid balance when payments are made on a monthly basis. Their charge covers interest and cancellation insurance. If payments are made annually, the interest rate is 4.12 percent of the unpaid balance.

Commercial banks usually charge six percent per year on the unpaid balance plus a one dollar filing fee if paid monthly. The loan is covered by cancellation insurance with the premium included in the six percent interest charge.

Annual Milk Cooling Cost

The second cost of interest to farmers considering conversion to a bulk system is the cost of operating the bulk tank. To determine the net returns or net losses associated with a bulk system, the total cost of operation must be computed with reference to a specific period of time and in relation to a specific volume of milk. All cooling costs were computed on an annual basis and in terms of cost per hundredweight of milk.

The factors that influence the total cost of performing any process may be divided into two classes, variable and fixed. The fixed factors are those which would be incurred even if no output occurred, while the variable cost factors are usually defined as those costs which depend on the output of the process. Information was obtained from bulk tank owners, engineers, and Central Oklahoma Milk Producers Association to determine the level of these costs.

Fixed Costs

Once the farmer has purchased the bulk tank, he will incur certain costs regardless of the amount of milk cooled. These annual costs are (1) depreciation, (2) interest on investment, (3) taxes, and (4) insurance.

Depreciation. Depreciation is the loss in value and service capacity resulting from natural wear in use, obsolescence, accidental damage, rust, corrosion, and weathering.[2] Because of the rapidly changing technology

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[2] F. C. Fenton and G. E. Fairbanks, The Cost of Using Farm Machinery, Kansas State College Engineering Station Bulletin No. 74, (Manhattan, Kansas, September, 1954), p. 15.

in the dairy industry, obsolescence is of particular importance with a long-term, high cost investment such as the bulk tank.

Bulk milk tanks have not been in operation on Oklahoma farms for a sufficient length of time to arrive at an accurate estimate of their expected life. Studies in other states have indicated an expected life of 10 to 20 years for the tank and an average life of 10 years for the compressor. Servicemen at Central Oklahoma Milk Producers Association estimate the tank life at 20 years and the compressor at 10 years. An average of owners' estimates from the producer survey indicates an expected life of 14.5 years for the tank and 9.3 years for the compressor.

Based on these estimates and the advice of agricultural engineers, the following procedure was used in determining annual depreciation schedules for 10 sizes of tanks. The average price of the tank and of the compressor installed was determined. A salvage value of five percent was allowed on both the tank and the compressor and deducted from their original costs. The remainder was depreciated on the basis of a life expectancy of 15 years for the tank and 10 years for the compressor. Straight line depreciation (equal amount for each year) was used in both cases. The results are indicated in Appendix Table II.

To find the average annual cost of bulk tank depreciation on farms in the sample, this same procedure was applied to the average size tank reported by these producers. The average yearly depreciation for all producers in the sample was $163.77 (Table XI). The range was $133.62 for farms in group A to $222.33 for farms in group E.

Table XI

Estimated Annual Cost for Bulk Milk Cooling,
Oklahoma City Milkshed, 1957

Item	Total	Group A 0-10,000	Group B 10-15,000	Group C 15-20,000	Group D 20-30,000	Group E > 30,000
Fixed Costs						
Depreciation	$163.77	$133.62	$138.26	$163.92	$162.57	$222.33
Interests on investment	56.19	51.54	53.48	63.34	62.78	85.25
Taxes	21.00	17.67	19.15	21.24	20.28	25.98
Insurance	6.66	5.60	5.87	6.73	6.43	8.23
Total Fixed Costs	$247.62	$208.43	$216.76	$255.23	$252.06	$341.79
Variable Costs						
Electricity	$ 72.81	$ 28.46	$ 44.26	$ 60.96	$ 84.72	$145.64
Labor	53.35	40.48	42.40	53.96	51.52	57.62
Repair	51.85	42.48	43.67	51.89	51.53	71.64
Cleaner and sanitizer	35.76	31.09	32.56	35.81	35.52	40.39
Total Variable Costs	$213.77	$142.51	$162.89	$202.62	$223.29	$315.29
Total Costs	$461.39	$350.94	$379.65	$457.85	$475.35	$657.08
Average Costs/Cwt. Cooled	.1796[a]	.3495[b]	.2431[c]	.2129[d]	.1590[e]	.1279[f]

[a]Average annual production = 2568.66 cwt.

[b]Average annual production = 1004.18 cwt.

[c]Average annual production = 1561.59 cwt.

[d]Average annual production = 2150.63 cwt.

[e]Average annual production = 2988.78 cwt.

[f]Average annual production = 5138.09 cwt.

Interest on Investment. The costs of resources to a firm are their values in their best alternative uses. Money used to purchase a bulk tank cannot be used in other productive uses; therefore, interest on investment is considered as one of the costs of ownership.

In estimating the costs of owning a bulk tank, it is convenient for the present analysis to compute an interest charge that is constant or equal throughout the life of the tank. This may be accomplished by making an annual interest charge on the average investment in the tank over its full life. The average investment is equal to one half of the sum of the original cost plus salvage value.[3] For example, the annual investment costs for a 100 gallon tank would be $\frac{\$1,437.21 + \$71.85}{2} = \$754.53$. In this study the interest was assumed to be five percent per year. Therefore, the interest on investment for a 100 gallon tank would be $37.73 ($754.53 x 0.05 = $37.73). The results for 10 sizes of tanks are shown in Appendix Table II.

This procedure was employed for determining the interest on investment component of annual fixed cost for each of the farms in the survey. The average investment cost per farm for each of the strata in the sample was determined by using the average size tank reported by farmers in that group. These results are shown in Table XI.

Insurance Costs. While it is not a universal practice to insure milk cooling equipment, the insurance charge appears justifiable. If a farmer does not insure, he carries the risk himself. Bulk tanks may be insured

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[3] Ibid., p. 15.

by an individual hazard policy or by a policy covering all farm buildings and equipment. If the tank is financed, a hazard insurance policy is required for the duration of the loan. The rate charged by Central Oklahoma Milk Producers Association in its financing plan is 1.05 percent of the unpaid balance for a period of three years or 0.33 percent per year.

Based on engineering reports, an annual charge of 0.25 percent of the initial cost appears to be a more suitable estimate.[4] This charge was used in computing the estimates for 10 tank sizes (Appendix Table II).

The average annual cost of insurance for the producers in the sample was computed by applying the 0.25 percent rate to the average tank cost. The annual cost of insurance for all producers averaged $6.66 per farm. The range was from $5.60 for farms in group A to $8.23 for farms in group E (Table XI).

<u>Taxes</u>. Farm machinery is taxed at the same rate as other farm property. The tax rate, which varies widely with locality, is applied to an assessed value of the machine. For purposes of cost estimating, a constant average yearly charge of one-half to one percent of the first cost is commonly assumed.[5]

In Oklahoma, each school district has an independent tax levy. The Payne County Assessor's office in Stillwater reported a range of $3.50 to $5.40 per $100 assessed valuation for machinery in these districts with an assessed value at approximately 30 percent of the original cost.

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[4] Roy Bainer, R. A. Kepner, and E. L. Barger, <u>Principles of Farm Machinery</u>, (New York, 1955), p. 35.

[5] <u>Ibid</u>., p. 35.

For this study, a uniform tax rate of $4.50 per $100 assessed value and an assessed value of approximately one-third the average investment were used to determine taxes. The average investment was one-half the sum of the original cash price installed plus salvage value. The assessed valuation of the bulk tank was placed at about one-third this average investment. The tax rate of $4.50 per $100 was applied to this assessed value to obtain the annual tax. Taxes for each of the 10 sizes of bulk tanks are shown in Appendix Table II and appear to be consistent with the range of one-half to one percent of the first cost.

This same procedure was used to determine the taxes for farms in each of the sample strata. The average tax cost per farm for all farms was $21.00 per year (Table XI).

Variable Costs

Variable or operating costs are incurred as a result of actual bulk tank operation. The four variable cost items considered in this study are: (1) electricity, (2) repair, and (3) labor and materials used in cleaning the bulk tank.

Electricity. One of the more important variable costs of cooling milk is electricity. Previous studies in other states have indicated that a lower cost for cooling milk generally may be expected with a bulk tank. The number of kilowatt hours per hundredweight of milk cooled depends upon: (1) amount of milk cooled and the temperature to which it is cooled, (2) size of the tank, (3) percent of capacity of the tank used, (4) type (direct expansion or sweet water), (5) condenser cooling method (air, air-water, or water), (6) horsepower of compressor motor, (7) frequency of pick-up, and (8) season of year.

A number of electrical consumption tests have been completed on bulk tanks. In all tests approximately the same results were obtained. One of the most comprehensive studies was conducted at Michigan State University by Carl W. Hall.[6] A plan to adapt this data to Oklahoma conditions by inflating the kilowatt consumption rate by a temperature factor was abandoned because of the large number of unknown elements in the original research. Instead, it was decided to install check meters on several tanks in the Central Oklahoma area. Assistance was obtained from Elmer Daniels of the Agricultural Engineering Department and Dave Goodrich and other personnel from Central Rural Electric Co-operative. The latter organization also supplied the equipment for this test.

Four farms were selected to represent a diversity of operating conditions. The kilowatt meters were read monthly, and the monthly pounds of milk sold by each farm were obtained from the co-operative associations. One gallon of milk per day, the estimated home use, was added to sales to obtain the total amount cooled. The average number of kilowatt hours used per hundredweight of milk cooled was 1.1338 (Table XII). The kilowatt hours per hundredweight of milk for the individual farms ranged from .8050 to 1.7343 and are shown in Table XII.

The bulk tank with the lowest consumption rate appeared to be operating under the most ideal conditions. The tank was of the direct expansion type, with the condensing unit cooled by air and water, and with a high

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[6] Carl W. Hall, "Bulk Milk Pickup Electrical Costs," Milk Plant Monthly, May, 1955, p. 4.

Table XII

Metered Electricity Consumption and Costs for Four Bulk Milk Tanks, Oklahoma City Milkshed, 1958

Meter Number	Time Period of Test	Percent of Tank Utilization	Amount of Milk Cooled (cwt.)	KWH Consumed	KWH Per Cwt. of Milk	Avg. No. of Kilowatts Used Per Day	Avg. Cost Per Farm Per Day (cents)
3[a]	Aug.1-Nov.3	87.81	1373.296	1105.5	.8050	16.328	46.3
1[b]	July 25-Nov.3	66.58	554.146	667.0	1.2036	6.588	18.7
2[c]	July 25-Sept.30	85.45	587.910	830.5	1.4126	12.563	35.6
4[d]	Aug.1-Nov.3	26.51	414.586	719.0	1.7343	7.543	21.4
Total			2929.938	3322.0		43.022	
Average		66.59	732.484	830.5	1.1338	10.755	30.5

[a] 500 gallon Creamery Package tank, direct expansion, compressor installed remote, air and water cooled. Compressor motor - 3 H.P., 27.5 amps, agitator motor-1/3 H.P., 5.6 amps, two fan motors.

[b] 255 gallon Zero tank, direct expansion, compressor attached air cooled. Compressor motor, 1 1/2 H.P., agitator motor 1/8 H.P., 2.6/1.3 amps, two fan motors.

[c] 250 gallon De Laval tank, direct expansion compressor attached, air cooled. Compressor motor,3 H.P., agitator motor 1/6 H.P., amps 3.6, two cooling fans.

[d] 500 gallon Zero tank, direct expansion, compressor installed remote, air cooled. Compressor motor, 3 H.P., 19 amps, agitator motor 1/6 H P., amps 3.41, two fan motors, 1/12 H.P., 1.8 amps.

Source: Results of experiment conducted on four Central Oklahoma Dairy farms, August, September, and October, 1958.

percentage utilization. The relatively high consumption rate for the two smaller tanks could have been due to the fact that the condensing units were inside the milkroom and were cooled entirely by air. The fourth tank was operated under what should have been favorable conditions but the consumption rate per hundredweight of milk cooled was high.

The high consumption rate for the fourth tank may have been related to the low utilization of 26.5 percent of capacity. Studies by Hall and others have indicated that utilization rate is of no great importance in the consumption of electricity but these figures would indicate otherwise. To check on this possibility, the percentage utilization by months was computed for this tank. The percentage utilization for August was 16.61 and the kilowatts per hundredweight were 2.5287; for September, the percentage utilization was 24.39 and kilowatts per hundredweight were 1.1570; for October, the percentage utilization was 41.07 and kilowatts per hundredweight were 1.0042. Thus, as production and the percentage utilization increased, the consumption of electricity per hundredweight of milk decreased. Some of the decrease, particularly from the large August consumption rate, probably was caused by the lower outside temperatures. However, a decrease this large is not likely from temperature change alone. It would appear from these data that tank utilization, at least at low levels of use compared with high levels of use, may have some effect on electrical costs per hundredweight of milk cooled.

The seven direct expansion tanks with every-other-day pick-up used in the Michigan study are shown in Table XIII. The average utilization was 57 percent of tank capacity with an average tank size of 277 gallons. The average kilowatt hour per hundredweight of milk cooled was .9728.

Table XIII

Bulk Milk Tank Utilization and Electricity Consumption, Michigan, 1955

Tank Description	Time Period of Test	Percent of Tank Utilization	KWH Per Cwt. of Milk
200 gallon, direct expansion, 2 H.P. compressor motor, air cooled	June-March	62	.75
200 gallon, direct expansion, 3/4 H.P. compressor motor, air cooled	April-August	62	.95
200 gallon, direct expansion, 3/4 H.P. compressor motor, air cooled	April-August	60	.86
300 gallon, air cooled	May-August	36	.87
300 gallon, air cooled	May-August	73	1.25
200 gallon, 1 1/2 H.P. compressor motor, air and water cooled	April-August	43	1.03
400 gallon, 2 H.P. compressor motor, air and water cooled	April-June	63	1.10
Average		57	.9728

Source: Carl W. Hall, "Bulk Milk Pickup Electrical Costs," Milk Plant Monthly, May, 1955, p. 4.

This compares with an average of 1.1318 kilowatt hours for the four tanks observed in Oklahoma. If consideration is given to the normal temperature differences between Michigan and Oklahoma it would appear that the results of these two experiments are not significantly different.

To determine the cost of cooling milk by the bulk system, the kilowatt consumption rate was assumed to be constant at 1.1338 kilowatt hours per hundredweight of milk cooled. With an assumed rate of 2.8345 cents per kilowatt hour, the cost per hundredweight was estimated at 3.2138 cents.[7] Evidence from the Michigan study shows that cost of cooling with an ice-bank tank is 1.97 cents per hundredweight greater than for a direct expansion tank.

Repair Costs. Farmers using bulk milk tanks reported few operational breakdowns. Since installing the tank, 33 of the producers have had some repair work performed on the tank. A total of 71 service calls were made for these producers and the addition of freon gas to the compressor unit was the most frequent service performed. Several tanks have needed repair work on the agitator motor or switch.

Thirty-five producers had a service contract with Central Oklahoma Milk Producers Association. The cost of this contract was $25.00 per year. The contract covers all mileage, time, and labor used in repair of the installed tank. All materials and parts used are charged at the wholesale cost rate plus 25 percent. Refrigerant gas is charged at the

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[7]The average cost of 2.8345 cents per kilowatt hour may overstate the electrical cost for producers utilizing large quantities of electricity. If an average cost of 2.5 cents per kilowatt hour is used, the annual electrical cost would be reduced about $3.00 for the smallest producers and about $32.00 for the largest producer. In both cases the reduction would be less than one-half cent per hundredweight of milk cooled.

rate of one dollar per pound. Twenty producers reported all repair charges covered by the contract and eight reported payment for repair parts. Seven farmers did not know if additional charges were made for service calls.

Repair costs for the compressor were separated from those of the tank in computing an annual repair cost for bulk milk tanks. Compressor repair costs were set at 50 percent of the original cost of the unit with this amount spaced equally over its useful life of 10 years. Repair costs for the tank were set at 25 percent of the original cost of all components other than the tank (cash price basis) with this amount spaced equally over a 15 year period. The annual repair cost for each size tank was the sum of these two estimates. Annual repair cost for 10 sizes of tanks are indicated in Appendix Table II.

The same procedure was used to estimate repair costs for the average size tank for all producers and for each group of producers. The average annual repair cost was $51.85 per farm. The average cost for farms at each of the five levels of milk production is indicated in Table XI.

Cleaning Cost. Cleaning cost in this study was defined to include a charge for labor used in cleaning the bulk tank and the cost of cleaning supplies used in this operation. The cost of cleaning and preparing the bulk tank for re-use was considered a variable cost. In a sense this cost is fixed, assuming the tank is used at all, since approximately the same amount of work and supplies were used with any quantity of milk.

In this study, 90 percent of the farmers were of the opinion their cleaning time had decreased since converting to a bulk system. The average bulk tank cleaning time reported by these producers was 16 minutes per tank with a range of five to 35 minutes per tank.

A least squares equation was employed to estimate the number of minutes required to clean the bulk tank. The size tank reported on each of the 50 sample farms was chosen as the independent variable (X) and the farmer's estimate of time required to clean the tank was taken as the dependent variable (Y). The resulting equation was

$$\hat{Y} = 10.875 + \underset{(.06315)}{.1460}\ X.$$

When milk is picked up every-other-day, the bulk tank must be cleaned approximately 15 times per month. The time spent in cleaning a given size tank per year may be obtained by multiplying the least squares estimate of time per pickup by 180, the approximate number of pickups per year. A labor charge of $1.00 per hour was assumed in computing the annual labor cost. The annual cost for each of 10 sizes of tanks is shown in Appendix Table II.

The labor cost for farms in each of the sample strata was determined on the basis of the average size tank reported by farmers in that group. The cost for the average tank size was computed by interpolating between the nearest tank sizes in Appendix Table II. This cost ranged from $40.48 for farms in group A to $57.62 for farms in group E.

The cost of cleaning and sanitizing supplies was computed by essentially the same procedure. However, only 22 producers could estimate their monthly cost for this item. The tank size reported on each of these farms was selected as the independent variable (X) and monthly cost of supplies as the dependent variable (Y). The estimating equation was $\hat{Y} = 2.281 + \underset{(.023655)}{.01987}\ X$. The estimate for a given size tank was multiplied by 12 to convert this estimate to an annual basis. The results for 10 sizes of tanks are indicated in Appendix Table II.

The cost of cleaning supplies for farms in each of the sample strata was determined on the basis of the average size tank reported in that group. The annual cost for cleaning supplies for farms in the total sample and each strata are included in Table XI.

Total Costs

The annual cost of cooling milk with a bulk tank for the sample farms is the total of each of the elements of fixed and variable costs in Table XI. For all producers interviewed, the average cost per year was $461.39 per farm.

The average cost per hundredweight of milk cooled at each of the five levels of milk production was also computed (Table XI). The average cost per hundredweight of cooling milk with a bulk tank decreased as output of milk per farm increased. Because of the limited range of observations in this study, the average cost per hundredweight decreased for all levels of milk production considered.

Annual Revenue From the Bulk Tank

Most dairy producers in the Oklahoma City milkshed have been able to realize additional revenue from converting to a bulk tank. In considering the conversion, dairymen are interested in knowing the level of milk production necessary for these added returns to exactly offset the added costs of the bulk tank. Determination of this "break-even" output will give dairy farmers the needed economic criterion by which they can estimate the profitability of conversion on individual farms.

Possibilities of added returns from the conversion may come from several sources. Among these are: (1) a premium paid on bulk milk, (2) savings in hauling costs, (3) less milk loss through spillage, (4) decrease in bacteria count, and (5) higher butterfat test. Information was obtained from farmers with bulk tanks and from previous research at this station to estimate the magnitude of the additional revenue from these sources.

Bulk Milk Premium

At the present time, bulk producers are receiving 10 cents per hundredweight more for their milk than the same quality milk shipped in cans. Arguments for this premium stem from two sources. First, it is a payment to farmers for producing a better quality milk. Second, it is an aid for financing the conversion by shifting part of the milk plants decreased handling cost directly to the farmers.

The added returns from the premium was determined by multiplying the annual production of milk by 10 cents per hundredweight. The average annual revenue from this source was $256.87 for all producers (Table XIV). For farms in group A, the average revenue was $100.41 per year. Farms in group E, with a much larger volume of milk per year, received $513.81 from the bulk premium.

Savings in Hauling Costs

Since May 5, 1955, the Central Oklahoma Milk Producers Association has been directly involved in the hauling of bulk milk. Currently, the charge for hauling is based on a zone rate with Oklahoma City as the focal point. Zones are established on the basis of 20 air mile intervals.

Table XIV

Estimated Returns from Conversion to Bulk Tanks, Oklahoma City Milkshed, 1957

Item	Total	Group A 0-10,000 Pounds	Group B 10-15,000 Pounds	Group C 15-20,000 Pounds	Group D 20-30,000 Pounds	Group E > 30,000 Pounds
Premium at 10¢ per cwt.	256.87	100.41	156.16	215.06	298.88	513.81
Savings in hauling cost	410.98	160.67	249.85	344.10	478.20	822.09
Savings in milk losses	43.61	17.04	26.50	36.49	50.71	87.18
Total Annual Returns	711.46	278.12	432.51	595.65	827.79	1423.08

Producers who are located in the interval between two circles are charged the same rate per 100 pounds of milk.

Hauling costs were less under the bulk tank system than under the can system for 49 of the 50 producers. The average cost for hauling milk in cans for these producers was 46 cents per 100 pounds of milk at the time of conversion. At the time of the survey, these same producers were paying an average of 30 cents per 100 pounds for milk hauled in bulk form. This is an average saving of 16 cents per hundredweight of milk sold. Based on the average milk production in 1957 for all sample producers, the savings in hauling costs was $410.98 per farm. The average annual savings on farms in each of the five groups is indicated in Table XIV.

The savings in hauling costs will vary among producers according to their distance from Oklahoma City and their location in a pricing zone. There may be no savings for producers close to the market and there may be an increase in hauling rates in some instances. Generally, savings are greatest for those producers located on the periphery of the milkshed.

Savings Obtained From Avoidance of Milk Losses

When milk is sold in cans, the farmer is paid for the volume of milk delivered at the receiving plant. Generally, there is some loss of milk from two sources: milk which is spilled when handling cans, and milk which sticks to the inside of the milk can and does not drain out during the dumping process. Any milk loss from either of these sources is the farmer's loss.

When milk is sold in bulk, the farmer is paid for the volume of milk that is measured in the farm tank. The milk losses associated with cans are eliminated from the farmer's payment. The elimination of this loss by conversion to a bulk tank represents a saving to farmers from this system and hence, an increase in total farm revenue.

The results of a research project by the Department of Dairying at Oklahoma State University were used to estimate the added revenue from this source.[8] These results indicated an average of 0.32 pounds of milk lost from each 10 gallon milkcan. The 0.320 pounds of milk lost per can was applied to the number of ten gallon cans that would have been used for 1957 milk sales if each were filled to capacity. By this procedure, the average sample producer would have lost 956.4 pounds of milk that year. With an average blend price received in Oklahoma City in 1957 of $4.56 per hundredweight, the average producer would have lost $43.61 if he were using cans (Table XIV). Since he did not incur this loss with a bulk tank, this amount represents added revenue accruing from the conversion.

Savings Obtained From a Lower Bacteria Count

Evidence indicates that most raw milk cooled in a bulk tank has a lower bacteria count than milk cooled in cans. Apparently this results from the faster cooling rate and more effective cleaning associated with the bulk tank. Johnson found an average standard plate count of 54,700 for raw milk handled in cans as compared with a plate count of 17,400

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[8] P. E. Johnson, H. C. Olson, and R. L. VonGunten, A Comparison of the Bulk and Can Systems for Handling Milk on Farms, Agricultural Experiment Station No. B-436 (Oklahoma State University, August, 1954), p. 13.

for similar milk cooled in bulk tanks.[9] The decrease of 37,300 in the plate count was attributed to the bulk tank. He also reported that only six of 51 bulk counts were higher than 50,000, while 25 of 50 were higher than 50,000 when milk was cooled in cans.

Forty-four of the producers interviewed reported a decrease in bacteria count after installation of the bulk tank. Many producers could not estimate the amount of decrease, but all considered that one of the prime advantages of bulk handling was the better quality milk produced. For the 17 producers who estimated the decrease in bacteria count, the average decrease was 50,735 per farm.

While evidence exists that additional revenue may be obtained on some farms from this source, the amount would be negligible and is not considered in determining the break-even output. Dairymen, who consistently experience difficulty producing milk below the minimum allowable plate count with cans likely would benefit most from installing a bulk tank.

Savings Obtained From a Higher Butterfat Test

When milk is cooled in either cans or a bulk tank, a certain amount of cream adheres to the sides of the container and is lost. The amount lost in cans is markedly greater, since a larger surface area is exposed to the milk and the rising cream adheres to the can lid. If less fat is lost by conversion, the same monetary result is obtained as increasing the test of milk from bulk tanks. This added return would represent revenue imputed to the conversion.

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[9] _Ibid._, p. 8.

Only 38 percent of the farmers had noticed any increase in milk test since installing the bulk tank. These producers reported an average increase of 0.25 points per hundredweight.

Because of the small number of producers reporting an increase in the test and the conflicting reports from previous studies, revenue from this source was not included in the analysis. However, increased revenue from higher test milk may be obtained on some farms.

Total Returns

Dairy producers may obtain greater revenue from five major sources by adopting bulk milk handling. It is unlikely that a single farm will benefit from each of these possibilities, but evidence indicates that nearly all farms will benefit from three of these.

The average revenue that may be obtained from the bulk premium, savings in hauling cost, and savings in milk losses was computed for 1957 milk production on farms in each of the sample strata. The range in total annual returns was $278.12 for farms in group A to $1423.08 for farms in group E (Table XIV). The average annual revenue for all sample farms was $711.46. The average revenue per hundredweight of milk cooled was $0.2770 cents at all levels of milk production.

CHAPTER VI

DETERMINATION OF BREAK-EVEN VOLUME WITH BULK TANKS AND ESTIMATED NET PROFIT FOR VARIOUS LEVELS OF OUTPUT

Farmers contemplating the purchase of a bulk tank are vitally interested in the annual volume of milk necessary for possible savings to offset the added costs of the tank. An estimate of the break-even output would enable present can producers to determine the potential net profit from the conversion. The break-even volume may be defined as that output where the added costs of owning and operating a tank are exactly equal to added returns from the tank. With an output less than this, the farm would be incurring losses from the conversion; with an output greater than this, the farm would be obtaining profits from the conversion.

Estimation of Break-Even Volume

Estimation of break-even outputs involve the computation of an average cost and an average revenue function. The average cost function could be discrete or continuous and could relate the average cost per hundredweight for the bulk tank to each volume of output. The average revenue function also could be discrete or continuous and could relate the average revenue per hundredweight derived from the bulk tank to each volume of output. A break-even volume could be determined by equating these two functions.

Costs

Theoretically, the long run average cost curve for an industry may be defined as the envelope curve tangent to all possible firm short-run average cost curves. The long-run average cost curve thus represents the least cost combination for any output. Generally, the long-run average cost curve is "U" shaped. That is, the average cost for a small volume is high. It decreases with additional volumes at a decreasing rate until a minimum cost is reached. Alternatively stated, as each scale of plant becomes more and more efficient, the rate of decrease of the average cost function declines and eventually becomes zero at the minimum point of the long-run average cost curve. Thereafter, as output is increased, increasing inefficiencies, or diminishing returns to some fixed factor, cause the long-run average cost curve to slope upward. Under the assumption of optimum farm organization with all costs variable in the long run, the envelope curve or long-run average cost curve may be called the planning curve for the firms in an industry.

The annual average cost for the ownership and operation of the bulk tank on each farm was computed from survey data.[1] These costs are shown as symbols in Figure 5. Consistent with the theoretical curve, the average annual costs for the individual farm observations decrease rapidly with increases in output for small volumes which, in turn, indicate increased efficiency as output is increased. However, costs flatten out substantially at the larger outputs and the rate of decrease is quite

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[1]These costs differ from the costs in Chapter V in that they are derived from the cost of the tank size and make reported on each sample farm.

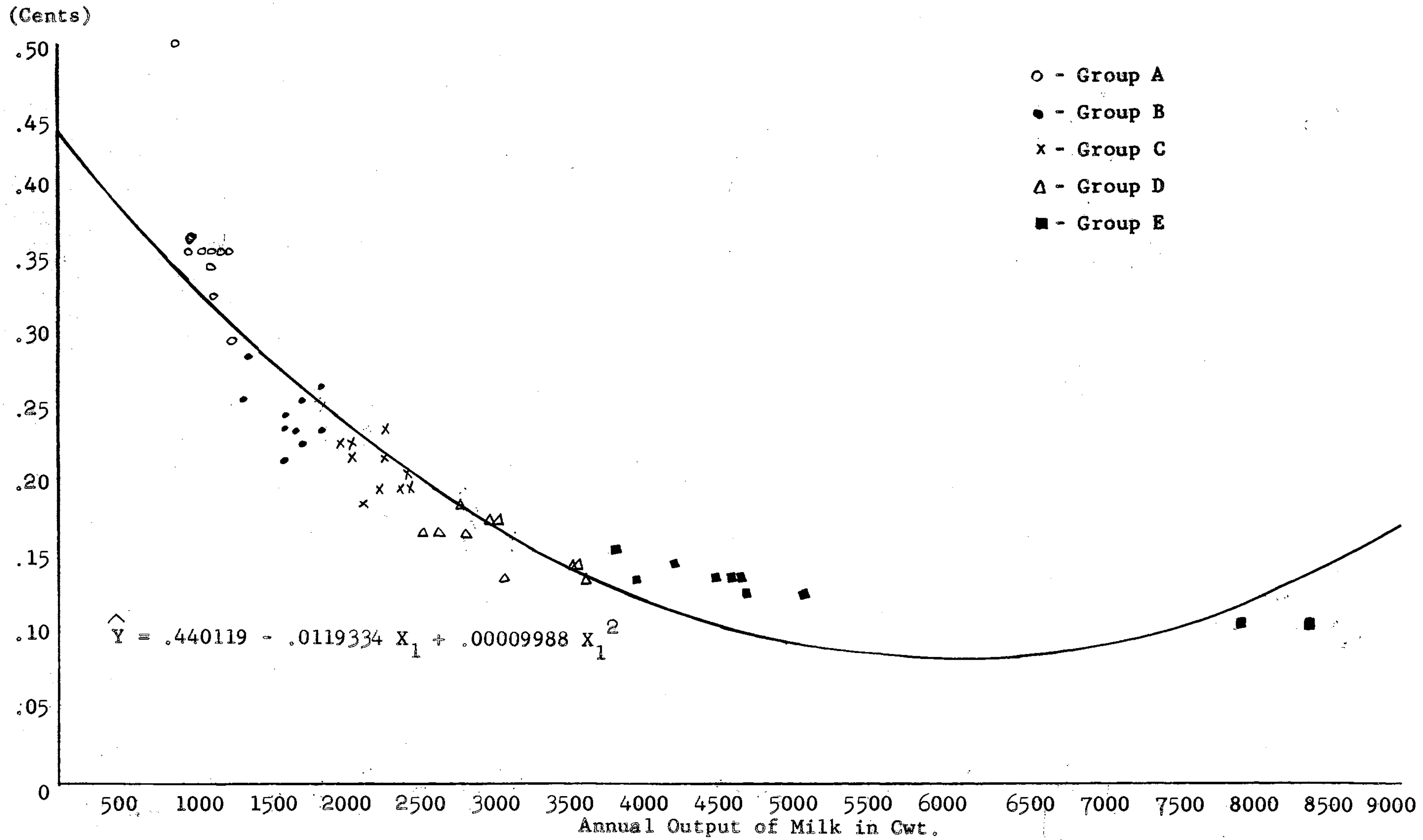

Figure V. Regression of Output on Average Annual Cost of Installing and Operating a Bulk Milk Tank, Oklahoma City Milkshed, 1957 small after an annual volume of 3,000 hundredweight is obtained. An increase in output from 3,000 to 8,400 hundredweight reduces the average cost by only about three cents per hundredweight (Figure V).

Contrary to the theoretical curve, there is no evidence that costs have reached a minimum point for the volumes observed. From the data, costs appear to approach a horizontal line or minimum at 11 cents per hundredweight. The lack of evidence for higher costs at larger volumes is frequently found in attempts to estimate empirical average cost functions. The lack of evidence may be due to three important factors. First, it is difficult to obtain observations over a range of sufficient size to obtain diminishing returns to a factor. Second, in most studies the assumption is made that factor prices are independent of output. Third, management may actually be at an optimum level for each firm so that inter-firm comparisons do not show increasing costs beyond some defined output. In practice, diminishing returns to an exogenous variable such as management are assumed for the construction of average cost functions.

An estimate was made of the long-run average cost curve from the sample observations. A second degree polynomial of the form $\hat{Y} = a - bX_1 + cX_1^2$ was selected as the type of equation to represent average costs for various volumes, where $\hat{Y}$ is the average cost per hundredweight and X_1 is the volume of milk per farm, in hundredweight. In computing this equation, the method of least squares was employed and the average annual cost of installing and operating the bulk tank for each of the sample farms was treated as a single independent observation. The fitted equation was as follows: $\hat{Y} = .440119 - .0119334\ X_1 + .00009988\ X_1^2$.

The statistical results lend support to the use of this equation for estimating average unit costs. The coefficient of determination (R^2) indicates that 83.4 percent of the variation in average cost was explained by this equation. Student's "t-test" indicates that both of the parameters, b and c, were significantly different from zero at the 99 percent probability level.

The graphic results of fitting the polynomial are shown in Figure V. The curve follows the dictates of economic theory in that the cost estimates conform to the principles of the hypothetical long-run average cost curve with an inverse relationship existing between output and costs up to the minimum cost per hundredweight of milk. The curve underestimates the cost for most producers in group A and overestimates the cost for producers with an annual volume greater than 7,500 hundredweight. The estimated minimum cost output, that at which the optimum scale of plant is achieved, is 5,973.88 hundredweight per year.

On the basis of economic theory and the statistical tests, the equation in Figure V will provide an estimate of the average annual total cost of installing and operating a bulk tank at various levels of output on farms in the Oklahoma City milkshed. A prospective bulk producer may compare his annual output with this average cost function and estimate the net cost of utilizing the bulk system.

Revenue

Average revenue, in the sense used to calculate a break-even volume of milk, is an average return per hundredweight of milk that a farm may earn from converting to a tank system. The items in such a computation include (1) a premium for bulk milk, (2) a lower hauling cost, and (3) a decrease in milk losses.

In Chapter V the average revenue imputed to the bulk system was determined for each of the sample strata. Based on the average returns per farm, this was 27 cents per hundredweight. Since the average returns per hundredweight were the same for each sample strata, the average revenue curve is a horizontal line or perfectly elastic schedule as illustrated in Figure VI. Under these average revenue conditions the farms gaining most from conversion to a bulk system would be the larger farms since costs decrease as the volume of production is increased. The greatest return was 19.33 cents per hundredweight at an output of 5,973.88 hundredweight.

The Break-Even Volume

If the costs of producing milk are equal with either a can or bulk system, the only relevant costs for determining the break-even volume after conversion are the extra costs associated with the installation and operation of the bulk tank. Since both the extra costs and the extra returns in Figure VI are directly associated with the bulk tank, they will provide the basis for estimating the break-even output per farm. The estimated annual volume at which the bulk tank will exactly pay for itself is 1,574.304 hundredweight, the intersection of the two curves in Figure VI. This is equivalent to 13,119 pounds per month or 50.8 gallons per day per farm. Farms with production less than this probably are incurring losses from the conversion and farms with production greater than this probably are making profits from the conversion. The difference between the two curves, average revenue minus average cost for each output, is the profit or loss per hundredweight associated with the conversion.

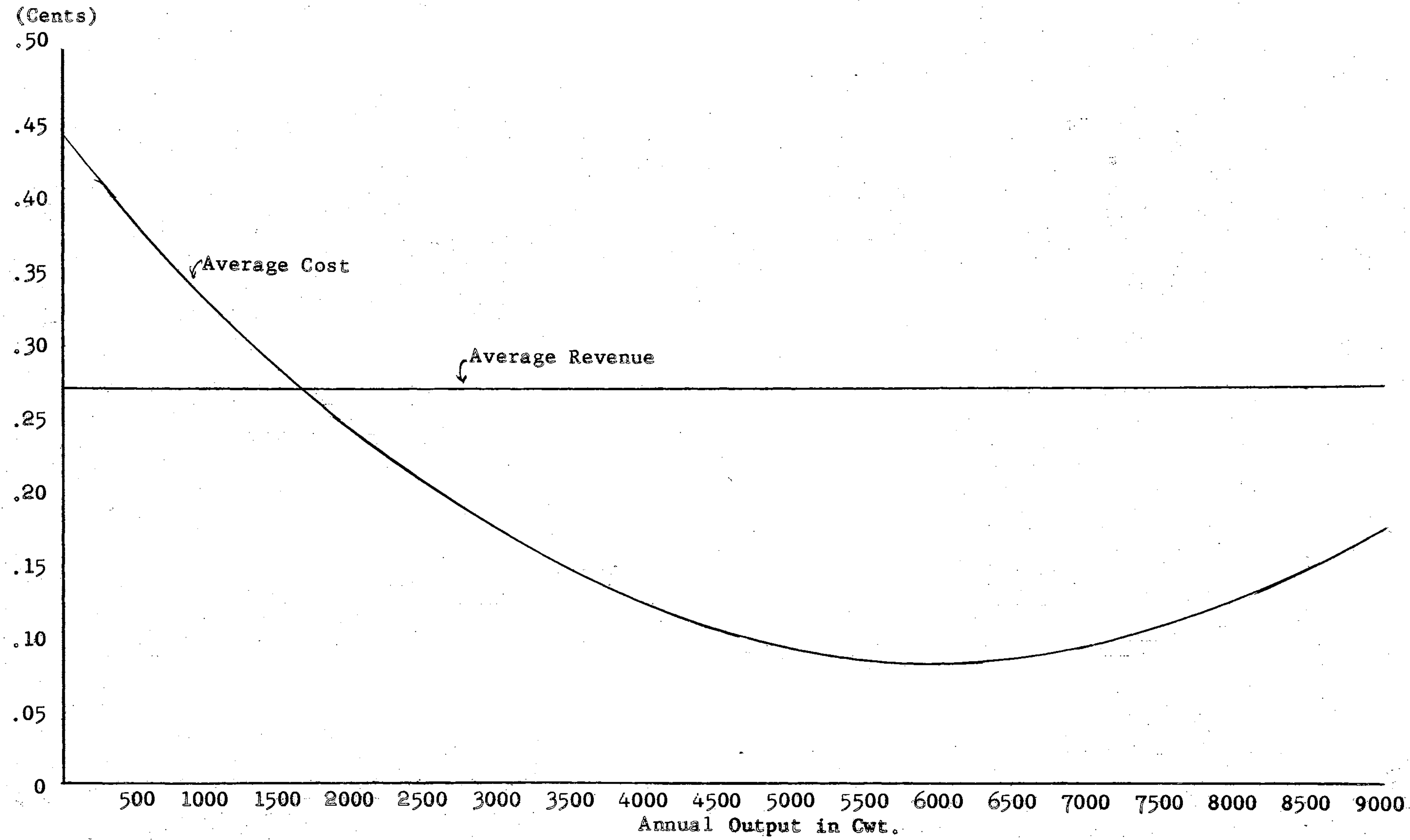

Figure VI. Estimated Average Costs and Average Revenue for Various Volumes of Milk Sold, Oklahoma City Milkshed, 1957

The break-even volume of about 51 gallons per day was estimated on the basis of average conditions found in the Oklahoma City milkshed. Farms with better than average capacity utilization percentages and cooling efficiency, and higher transportation cost differentials would have lower costs per unit and would find that the tank would pay for itself at a lower output. Conversely, farms with less efficient practices likely would not pay for the tank at the indicated output.

Even though a farm may be operating at less than the break-even volume, other circumstances may necessitate the conversion to bulk handling if the producer is to continue in production. For example, higher can hauling rates or decreasing market outlets for can milk in the future may force many farms to convert to bulk tank even though net losses would result from the conversion. In this case, the net losses may be smaller than those associated with going out of business.

The relationship between average revenue and average cost for each of the five size groups in the sample would provide some basis for anticipating changes in production. For the smallest size group, it would appear that individual producers with less than 10,000 pounds of milk per month are either increasing their production to achieve economies of large scale production or dropping the dairy enterprise. Producers with an output between 10,000 and 30,000 pounds per month are generally increasing output. For producers with volumes greater than 30,000 pounds per month, the bulk tank is such a minor part of total milk production expenses that perhaps it can be neglected in estimating changes in production. On the basis of tank costs alone, all producers would strive for an output of about 50,000 pounds per month. At this volume, savings from the conversion would exceed costs by approximately 19 cents per hundredweight.

Alternative Break-Even Volumes

The break-even volume in the previous section assumed average returns and costs per hundredweight from the conversion under specific assumptions. In order to extend the analysis to cover alternative assumptions or situations, the estimated costs and returns should be allowed to vary and the effect on break-even volume determined.

The first specific assumption was that bulk milk would obtain a premium of 10 cents per hundredweight over can milk. Both can and bulk producers have expressed doubts about the continuation of this premium after 100 percent coversion is attained. The discontinuation of the premium would have the effect of shifting the average revenue curve down by 10 cents per hundredweight, the amount of the premium. Thus, profits from conversion would be less (or losses greater) and the break-even volume would be greater. The average cost curve would intersect the new average revenue curve at a greater volume of output (Figure VII). The break-even volume under these conditions would be 2,917.015 hundredweight per year or 24,308 pounds per month.

From this estimate only 38 percent of the present bulk producers would have a volume equal to or greater than the break-even volume. Assuming that most of the remaining can producers are the relatively smaller ones, the conversion could not be justified on the basis of costs and returns alone if the premium were not in effect.

A second important element of the average revenue curve was the reduction in hauling costs attributed to the bulk system. It was assumed that the average reduction in hauling cost was 16 cents per hundredweight. Eliminating this 16 cents per hundredweight in the equation, average

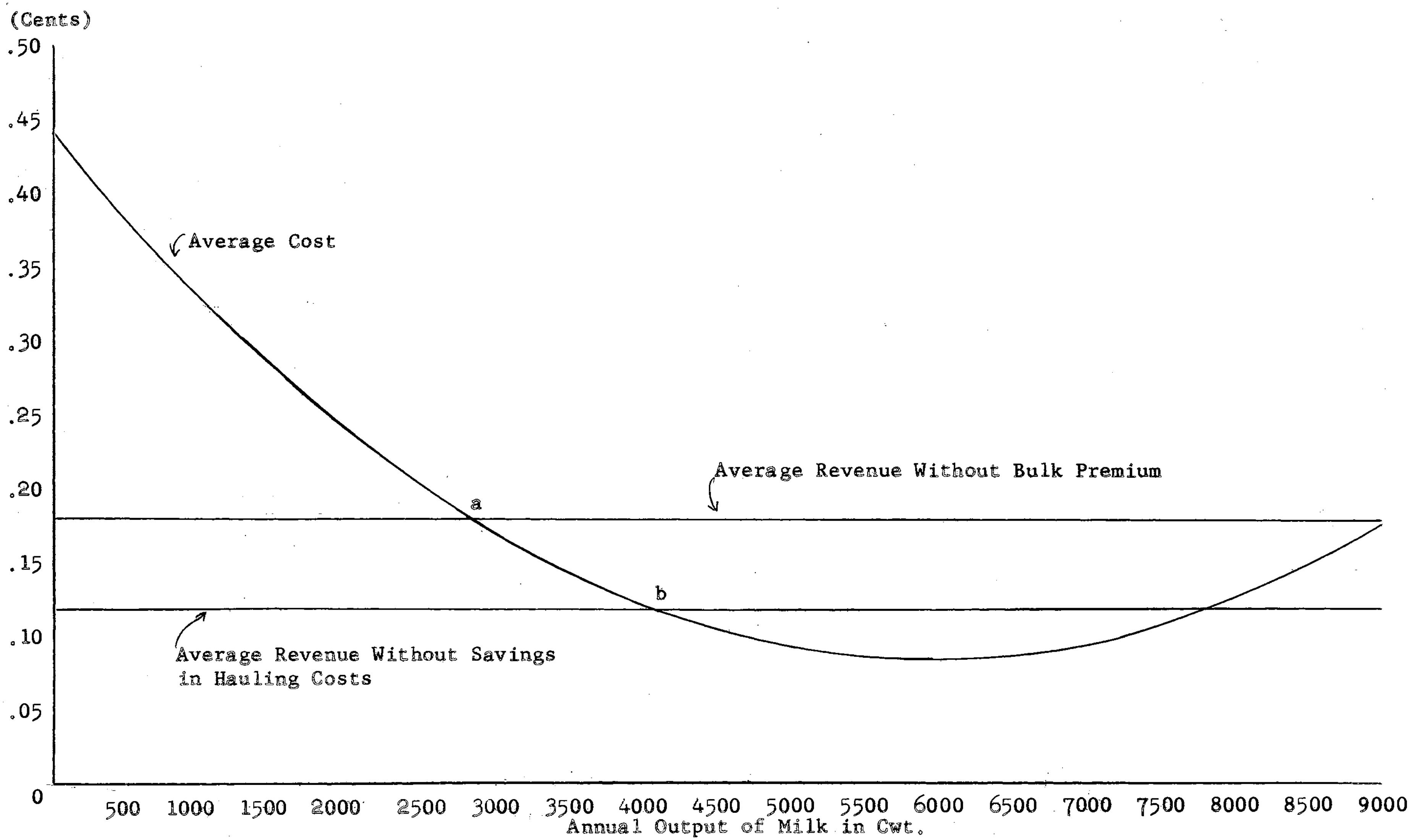

Figure VII. Estimated Average Cost and Alternative Average Revenues for Various Volumes of Milk Sold, Oklahoma City Milkshed, 1957

revenue would be .1170 cents per hundredweight. With the same costs as before, the break-even volume under this revenue assumption would be 4,147.192 hundredweight per year or 34,560 pounds per month (b in Figure VII). This is probably the most realistic revenue position to assume for producers living close to Oklahoma City. It would be difficult to justify the conversion on a strictly break-even basis for these producers. Conversely, producers living on the periphery of the market area reported savings up to 30 cents per hundredweight which would result in a much lower break-even volume than that indicated in Figure VI.

While these are only two of many variables that could affect the break-even volume, they are the most important from the standpoint of the individual producer. The third major source of savings, decreases in milk losses, was assumed to be about the same for any level of output.

Improvement costs, necessary before conversion, are more important on some farms than others. The annual improvement cost for farms in the sample averaged about $2.16. Because of the wide variation in the improvements needed and the relatively small importance of improvements when amortized over a period of 15 years, improvement costs were assumed to be the same as the salvage value of the can equipment shown in Table X. Since improvement costs and salvage values were offsetting, both were neglected in computing the break-even volumes. Although improvement costs considered as long term cost items may appear to be relatively unimportant, they may be quite important as initial outlay investment items. Improvement costs are a part of total initial investment costs and cannot be ignored. These costs may be particularly important to farmers with limited capital resources.

Comparison of Total Direct Costs and Returns at Five Levels of Production

In this study an attempt was made to estimate total direct costs and total returns for each of the five size groups in the sample. From these estimates, an indication of the effects on net profits of conversion to the bulk tank system could be obtained for each level of production.

To determine the costs of milk production, data obtained in the same area by Underwood was used.[2] It was assumed that three costs in his study must be covered by the returns in order to insure their continued use in the business of milk production. These costs were pasture, hand-fed feeds, and direct man labor on cows. These items normally account for three-fourths to four-fifths of the total cost of producing fluid milk. Only direct labor on the cows was included. Indirect labor such as producing and grinding feeds, repairing utensils, and the like was omitted. All costs were on an annual per cow basis.

Prices used by Underwood in computing these costs were for 1950. To reflect the generally higher level of prices existing in 1957, the feed costs were inflated by a factor of 1.1139.[3] This higher price level was the result of the higher level of prices of feed grains occurring in

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[2]F. L. Underwood, p. 19.

[3]This factor was computed in the following manner: The index of prices received by Oklahoma farmers for feed grains and hay for 1957 was divided by the index number of 1950 as was reported by G. P. Collins and W. G. Hill, Prices Received by Oklahoma Farmers, 1910-1957, Agricultural Experiment Station Processed Series P-297 (Oklahoma State University, June, 1958), p. 83.

the first half of 1957. Labor costs in Underwood's study averaged 94 cents per hour. This was increased to $1.00 per hour for this study. Pasture cost was left as originally computed.

Total direct costs were obtained for each of the sample farms in this study by applying the new prices to Underwood's estimates of costs per cow, then multiplying by the average number of cows (milking and dry) reported on farms in each of the sample strata. To this was added the total annual cost of installing and operating the bulk tank. Total direct costs per farm are shown in Figure VIII and Appendix Table III.

Total revenue for each of the strata was estimated from the average sales of milk per farm for 1957. The average blend price received in Oklahoma in 1957 of $4.56 per hundredweight was applied to this volume to obtain total revenue from milk sales (Figure VIII). The added revenue from converting to the bulk tank was obtained by multiplying the return of 27 cents per hundredweight by the sales of milk. Total revenue is the sum of total revenue from milk sales and the added revenue from conversion.

By comparing total revenue and total direct costs, net revenue at each of the five levels of production can be estimated. Farmers with production comparable with group A appear to be incurring net losses. Excluding tank costs and returns, the average annual net loss is $884.60. Installing a tank at this level of production only increases the loss to $964.39. Farmers of a size similar to those of group B, appear to be netting $576.15 per year over direct costs without the tank. Installation of a tank at this level of production increases net revenue over direct costs to $616.03. Converting to a bulk system in group C increases

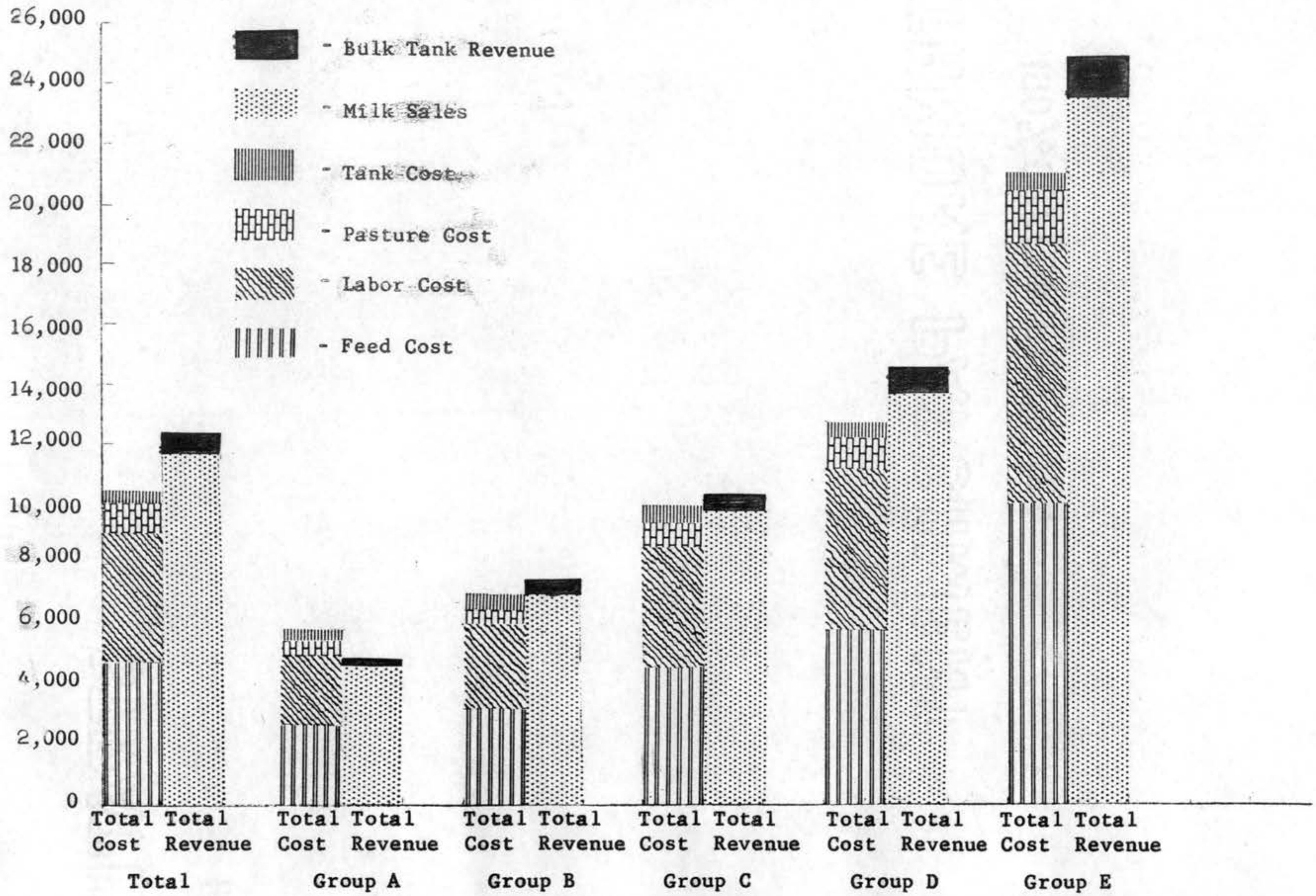

Figure VIII. Total Direct Costs, Total Returns and Returns from Conversion to a Bulk Tank, Oklahoma City Milkshed, 1957 net revenue over direct costs from $369.63 to $580.67. Farms with production comparable with group D increase net profit over direct costs from $1,415.95 to $1,747.57 by converting to the new system. Farmers in group E appear to be making the largest net profits. Net revenue over direct costs excluding the tank was $3,006.67 and after conversion to a tank system increased to $3,736.87. Viewed from the standpoint of the total sample average, net revenue over direct costs was $1,702.22 per farm excluding the effects of the tank. Under the bulk tank system, net revenue over direct costs was $1,934.15 per farm per year.

Two conclusions may be drawn from these figures. First, conversion to a bulk system increases net revenue per farm at all levels of production greater than 10,000 pounds. Actually, the increased revenue would come only after the break-even volume of 13,119 pounds per month. Net revenue added by converting is greater as output is expanded up to 5,973.88 hundredweight.

Second, the greater the production of milk per farm, the greater the net profit per farm for the farms in the sample. Individual farms with production below 10,000 pounds per month are losing money at present organizational levels. There is evidence that the smaller farms are increasing output or substituting a farm or non-farm enterprise for the dairy enterprise. These figures show net profits increasing in a linear fashion as output is increased. This may or may not be the case. Total revenue and total direct costs of production were computed assuming a constant return per cow. There may, however, be other factors on farms contributing to diseconomies of scale as the number of cows is increased.

If this is the case, the relatively advantageous position of the larger producers may be different from that shown in Figure VIII. Beyond some optimum output profits presumably will decline.

The net revenue estimates may be somewhat misleading in that labor is included as a direct cost of milk production. Since practically all labor and management on dairy farms in the survey were provided by the farm family, this is actually a residual return. In many farm management studies all costs of production except labor are subtracted from the value of the product and the remainder is the residual return to labor. In determining the relative profitableness of operating a dairy farm, the farmer must secure a return equal to or greater than he could obtain in his next best alternative, assuming no non-pecuniary motives. Therefore, a labor cost in the form of a rate per hour is included in this analysis. For this reason, a producer could remain in milk production at a loss in Figure VIII if he is willing to earn less than $1.00 per hour for his direct labor. However, due consideration must be given to costs not included in this study such as a return on capital items.

CHAPTER VII

SUMMARY AND CONCLUSIONS

The central problem of this study was to determine the volume of milk sales per farm at which possible savings from a bulk tank would be equal to the added costs of the tank. Additional objectives were to describe the typical farm organization for farms with bulk tanks at five levels of milk production and to investigate the profit above direct costs being made from the dairy enterprise by these farms.

The installation of a bulk tank has decided advantages for the larger farms and poses definite problems for the smaller farms. The advantages and disadvantages of the bulk tank system should be carefully weighed by each farmer considering conversion. Some of the more important advantages are:

1. Producers with bulk tanks receive a premium of ten cents per hundredweight of milk sold.
2. The average producer in the Oklahoma City area realized a saving in hauling costs of 16 cents per hundredweight.
3. There is less milk loss through stickage and spillage.
4. A better quality product is produced, especially from the standpoint of decreased bacteria count.
5. There is a possibility of increased butterfat test.
6. There is a decrease in cleaning costs.
7. Some of the manual labor associated with cleaning and lifting cans of milk is eliminated.

Some of the disadvantages are:

1. There is a high initial investment in the tank.
2. Some farms may incurr expense for improvements in milking facilities and roadways.
3. There is a possibility of losing four milkings if the milk is rejected.
4. Since all bulk milk is hauled by the Association, the can producer already on the market surrenders the individuality of his bargaining power to this organization when he converts to bulk but may gain more effective economic bargaining power through collective group action.

There are many other factors to consider when deciding whether or not a farmer should convert his dairy operation to bulk. An economic justification for converting exists only if the extra revenue from the tank would be equal to or greater than the extra cost of the tank. Unfortunately, the solution to the problem even in a purely economic framework is not the same for all producers.

The specific question of conversion must be answered for each farm after the characteristics of that farm have been considered. This study presents estimates of added costs and returns from bulk tanks based on the conditions found on 50 sample farms in the Oklahoma City milkshed. Results from this study indicate that farms presently using bulk milk tanks are larger in terms of acreage and number of dairy cows than Grade A dairy farms using cans in the Oklahoma City area. The production of milk per cow is also greater on these larger farms. The installation of a bulk tank appears to be related to the trend toward increased output per farm. These characteristics are similar to those reported in other milksheds. It is hoped that the estimates obtained from these sample farmers will provide the framework for making a decision concerning conversion even though each farm may have a unique problem solution for its average revenue and average cost conditions.

Bulk tank costs per farm were estimated from eight variables incorporated into an average cost function showing the relationship between annual cost and volume of output. A second degree polynomial was used to estimate the average total cost per hundredweight of using a bulk tank for any volume of output. From this equation the cost per hundredweight decreases rapidly until an annual output per farm of 3,000 hundredweight is attained. Thereafter, the decrease is small until the optimum output of about 6,000 hundredweight is reached. Beyond the optimum output the equation indicates increasing costs but the limited observations of this study do not substantiate the rising portion of the function.

Average revenue from the bulk tank was estimated at 27 cents per hundredweight at all levels of milk production. Revenue would vary on individual farms primarily from differences in savings in hauling costs.

An estimate of break-even volume was obtained from the average cost and average revenue curves (the point of intersection). The break-even volume for the average sample producer in this area was 13,119 pounds of milk per month. For farms with monthly production of milk less than this, the extra costs of the bulk tank likely are greater than the extra revenue. For farms with greater milk volume, the extra revenue probably exceeds the extra cost. Again, individual farm organization and management levels will influence the exact break-even volume on each farm.

An additional objective of this study was to compare total revenue from the dairy enterprise with the direct costs of milk production at five levels of output. These results indicated that farms producing less than 10,000 pounds of milk per month were not covering direct costs when a charge for family labor was included. This net loss was increased by converting to bulk tank handling. Farms averaging more than 13,000 pounds of milk per month appeared to be operating at a net profit. Conversion to bulk handling increases the net profit earned annually for these farms. Average net revenue from milk sales over direct costs from the dairy enterprise for all sample producers was $1,702.22 per year. By converting to a bulk tank, this was increased to $1,934.15 per year.

It is evident from the findings that for Oklahoma dairy farmers a bulk premium and some savings in hauling costs are necessary if the conversion is to be made on a strictly economic basis. On the other hand, it would seem that no producer could afford not to convert if all Grade A milk shipped into Oklahoma City in the future is to be handled in bulk. While a value cannot be placed on the latter possibility, farmers must recognize this in making their long-range plans. Such a possibility leaves the smaller producer with four alternatives, two if he remains in the Grade A dairy business and two if he decides to stop dairy production. First, he may remain in dairying, convert to bulk handling, maintain his present production, and operate at an output at which gross revenue from the dairy enterprise is less than the direct costs of milk production. Second, he may convert and expand his output of milk. Third, he may elect to stop dairying, recombine his existing resources, and replace the dairy enterprise with a farm enterprise requiring less capital. Fourth, he may maintain other farm enterprises and substitute off-farm employment for employment in the dairy enterprise. In practice, anyone of the four alternatives may be used by an individual small producer. The adoption of bulk tanks on Oklahoma dairy farms may contribute to the trend toward larger farm units and the exodus of some of the less efficient producers.

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APPENDIX

Appendix Table I

Schedule of Itemized Costs of Installed Bulk Milk Tanks, Oklahoma City Milkshed, 1958

	100	150	200	250	300	400	500	600	800	1000
Tank and controls	966.67	1237.10	1379.45	1484.88	1650.54	1896.37	2250.16	2495.51	3170.21	3302.35
Compressor	251.10	251.10	292.67	291.68	350.30	407.31	424.81	525.50	606.33	641.58
Hose chute and brush	13.75	13.75	13.75	13.69	13.75	13.75	13.75	13.75	13.75	13.75
Warranty	5.45	4.40	4.40	5.77	7.15	8.80	8.80	11.55	11.55	18.70
Sales tax	24.74	30.13	33.80	35.92	40.43	46.52	53.95	60.93	76.04	79.53
Installation costs	130.00	150.00	140.00	136.67	150.00	150.00	150.00	181.25	206.67	215.00
Freight	23.00	31.32	35.54	40.10	48.25	57.75	67.19	76.27	88.17	103.08
Calibration	22.50	16.67	25.00	33.33	16.67	30.00	31.25	32.00	53.33	85.00
Cash price installed	1437.21	1734.47	1924.61	2042.04	2277.09	2610.50	2999.91	3396.76	4226.05	4458.99
Insurance-hazard[a]	15.09	18.21	20.21	21.44	23.91	27.41	31.50	35.66	44.37	46.82
Insurance-cancellation[b]	29.08	35.12	38.97	41.34	46.11	52.86	60.75	68.78	85.58	90.29
Finance charges[c]	147.14	177.58	197.04	209.07	233.13	267.27	307.14	347.77	432.67	456.52
Price installed with financing	1628.52	1965.38	2180.83	2313.89	2580.24	2958.04	3399.30	3848.97	4788.67	5052.62

[a] Computed for three year payment period at 1.05 percent of the unpaid balance.

[b] Computed for three year payment period at 2.25 percent of cash price installed minus ten percent down payment.

[c] Computed for three year payment period at 11.0 percent of (cash price installed plus hazard and cancellation insurance and minus ten percent down payment).

Source: Compiled from data collected from equipment manufacturers, retail distributors, and Central Oklahoma Milk Producers Association.

Appendix Table II

Schedule of Annual Costs of Owning and Operating Bulk Milk Tanks, Oklahoma City Milkshed, 1958

Tank Size (Gallons)	Depreciation[a]	Investment Cost[b]	Taxes[c]	Insurance[d]	Electricity Cost[e]	Cleaning Costs Labor[f]	Cleaning Costs Supplies[f]	Repair[g]	Total Annual Costs
100	$ 98.97	37.73	11.34	3.59	36.22	36.60	29.76	32.32	286.53
150	117.80	45.53	13.67	4.34	54.33	39.00	30.96	37.27	342.90
200	131.17	50.52	15.17	4.81	72.43	41.40	32.40	41.83	389.73
250	138.57	53.60	16.10	5.10	90.54	43.44	33.36	43.75	424.46
300	155.31	59.77	17.95	5.69	108.63	45.60	34.58	49.62	477.15
400	178.22	68.52	20.59	6.53	144.84	50.64	36.96	57.08	563.38
500	203.45	78.75	23.65	7.50	181.09	54.60	39.24	64.16	652.44
600	231.77	89.16	26.78	8.49	217.26	59.40	41.64	74.12	748.62
800	286.85	110.93	33.31	10.56	289.69	68.04	46.44	90.65	936.47
1000	302.72	117.05	35.15	11.15	362.11	76.44	51.24	95.70	1051.56

[a]Straight line depreciation is used. Five percent of original cost is allowed for salvage value. The remainder of tank cost is depreciated over a period of 15 years and compressor over a 10 year period.

[b]Annual interest rate charged at five percent on one-half original cost plus salvage value.

[c]Tax is figured at a uniform rate of $4.50 per $100 assessed valuation.

[d]Annual insurance charged at .25 percent of initial cost.

[e]Computed assuming optimum utilization of tank capacity of 72 percent and a kilowatt hour consumption rate of 1.1338 per hundredweight of milk cooled. The cost per kilowatt hour was $0.028345.

[f]Estimated by least squares analysis. Labor charge was $1.00 per hour.

[g]Fifty percent of compressor cost amortized over a 10 year life and 25 percent of tank cost over a 15 year period.

Source: Computed from survey data obtained from members of the Central Oklahoma Milk Producers Association, from records of the Association, and from bulk tank manufacturers and distributors, June, 1958 to September, 1958.

Appendix Table III

Estimated Direct Costs and Returns from the Dairy Enterprise for Sample Farms, Oklahoma City Milkshed, 1957

Item	Total	Group A 0-10,000	Group B 10-15,000	Group C 15-20,000	Group D 20-30,000	Group E > 30,000
Feed cost[a]	5,287.67	2,672.42	3,201.18	4,615.99	5,973.64	9,989.41
Pasture cost[b]	934.25	472.17	565.60	815.57	1,055.45	1,764.97
Labor cost[c]	4,588.00	2,318.80	2,777.60	4,005.20	5,183.20	8,667.60
Total Annual Cost	10,809.92	5,463.39	6,544.38	9,436.76	12,212.29	20,421.98
Total Annual Return[d]	11,713.09	4,579.08	7,120.87	9,806.87	13,628.86	23,429.69
Net before tank is installed	903.17	- 884.31	576.49	370.11	1,416.57	3,007.71
Added revenue from tank[e]	693.54	271.13	421.63	580.67	806.97	1,387.28
Cost of tank[f]	461.39	350.94	379.65	457.85	475.35	657.08
Net After Tank Is Installed	1,135.32	- 964.12	618.47	492.93	1,748.19	3,737.91

[a]Annual feed cost estimate of $142.91 per cow.

[b]Annual pasture cost of $25.25 per cow.

[c]Annual labor cost of $124.00 per cow ($1.00 per hour).

[d]Annual returns computed from average amount sold per group and price of $4.56 per hundredweight.

[e]Tank revenue computed from average amount sold per group and 27 cents per hundredweight.

[f]From Table XIII.

Source: Computed from survey data obtained from members of the Central Oklahoma Milk Producers Association and information from Oklahoma Agricultural Experiment Station Bulletin No. B-482.

Appendix Table IV

Regression Equations for Trends in Milk Production on Sample Farms, by Size Groups, August, 1956 to July, 1958[a]

For the 10 Sample Farms in Group:	Regression Equations	Standard Errors of the b Coefficients	Monthly Change in Milk Production Per Farm (Pounds)
A	$\hat{Y} = 92.002 - .60915\ X$	.29618	- 60.915
B	$\hat{Y} = 113.93375 + 1.18550\ X$	.50037	118.550
C	$\hat{Y} = 166.65738 + 1.35541\ X$	.6322	135.541
D	$\hat{Y} = 244.08038 + .45117\ X$	.45766	45.117
E	$\hat{Y} = 433.42362 - .45709\ X$	.91321	- 45.709

[a]Based on total milk sales per farm for this two year period.

Source: Information obtained from the records of Central Oklahoma Milk Producers Association.

VITA

Fred Allen Mangum, Jr.

Candidate for the Degree of

Master of Science

Thesis: COSTS AND RETURNS OF BULK MILK TANKS ON DAIRY FARMS IN THE OKLAHOMA CITY MILKSHED

Major Field: Agricultural Economics

Biographical:

Personal Data: Born near Zebulon, North Carolina, March 14, 1931, the son of Fred A. and Annie Rue Mangum.

Education: Attended grade and high school at Wakelon High School at Zebulon, North Carolina; graduated from Wakelon High School in 1949; received the Bachelor of Science degree from North Carolina State College, Raleigh, North Carolina, with a major in Agricultural Economics, in May, 1957; completed requirements for the Master of Science degree in February, 1959.

Professional Experience: Served in the United States Army from January, 1953 to January, 1955. Worked part-time for the Department of Agricultural Economics North Carolina State College from June, 1956 to September, 1957. Research Assistant, Oklahoma State University from September, 1957 to February, 1959.