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Selected Operating Costs for Storage Of Sorghum Grain

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summary

This is the third of three bulletins reporting the results of a study of sorghum grain storage and handling practices in Texas. The first dealt with marketing and on-farm storage; the second with commercial storage and handling practices. This bulletin reports the results of a study of the costs of commercial grain handling practices.

Three areas representing a cross section of physical and economic conditions under which sorghum grain is produced and stored in Texas were selected for study. These three areas produce more than 80 percent of the state's grain sorghum crop and have approximately 80 percent of the off-farm commercial storage capacity.

Texas is the leading state in sorghum grain production with almost half of the U. S. crop. Texas production has averaged around 250 million bushels in recent years. Off-farm grain storage facilities in Texas had a capacity of 910 million bushels on January 1, 1964. Stocks on hand at that time were 71 percent of storage capacity. Sorghum grain made up 79 percent of the grain stocks in storage. Since sorghum grain stocks were slightly more than double production, it was estimated that half of the sorghum grain handled by the elevators was received annually.

Eighteen elevators were selected for intensive study of storage costs and problems. During each of four visits to each elevator, grain samples were obtained for official grading and costs of labor, power and other expense items were obtained together with grain volume data.

Direct costs of grain storage are classified as fixed costs which include depreciation, interest on capital invested, taxes and insurance and variable costs which include electric power, fuel and direct labor. Although most of the elevators had both upright and flat storage, operators tended to hold grain in flat storage and ship out from upright storage. Since continuous storage data were required for this study, it was necessary to use data relating to flat storage.

The cost per bushel for receiving sorghum grain varies by size of elevator but not much by area. Fixed cost per bushel for small elevators was about 1.2 cents and variable costs about .6 cents or a total of about 1.8 cents. Medium-sized elevators had receiving costs of about 1.1 cents and large elevators .85 cents.

Loading-out costs are a little below receiving costs. Less equipment is involved and less power is used, but more labor is required. Fixed costs average about .8 cents and variable costs about .6 for small elevators, or a total of 1.4 cents. This dropped to .9 cents for medium-sized elevators and .8 for large elevators.

A considerable portion of the sorghum grain crop is harvested before the moisture content reaches safe storage levels. Quite commonly, artificial drying is used to reduce the moisture content. The extent of drying varies by areas because of differences in climatic circumstances at times of harvest. Costs were figured on the assumption that 2 to 3 percent moisture is removed in a continuous-flow dryer. With

volumes ranging from 25,000 to 400,000 bushels, the direct cost of drying ranged from 9 cents down to about 1 cent per bushel. Fixed costs account for most of the difference since variable costs tend to vary directly with volume.

The great increase in the need for storage led to the construction of many flat storage buildings. Quality maintenance in these buildings is mostly a matter of controlling moisture, temperature and insects. This is handled largely by aeration. In 1960, two-thirds of all storage space on the High Plains and four-fifths in the other two areas was equipped with aeration. It is used to remove harvest or dryer heat, to prevent molds and heating in wet grain prior to drying, to remove small amounts of moisture, to maintain the quality of grain during storage and to distribute fumigants uniformly in stored grains.

Costs of aeration show little difference in fixed costs per bushel by size of operation or by area. Most of the difference from area to area relates to differences in annual hours of operation caused by weather conditions. Variable costs show more relation to size and area but overall, costs per bushel for aeration range only from .3 cent to aerate a large volume on the High Plains, to .65 cent for a small volume in the Coastal Bend area. Thus, aeration does not constitute either a major or highly variable cost item.

The basic operation for quality maintenance in upright storage is turning. Currently all upright storage not equipped with aeration will turn stored grain from 1 to 4 times during the year. This provides an opportunity to inspect the grain, equalize the temperature and treat grain with a protectant. The basic equipment used for turning is used also in receiving, loading out, and moving grain. Costs per bushel for turning range from .5 cent for one turning to 1.4 cents for four turnings.

Insect control is a matter of primary concern to all grain storage operators. Under favorable conditions little more than aeration is required. However, poorly designed aeration, trashy grain or irregular grain depths may result in poor distribution of air, uneven cooling, moisture migration and moldy, insect-infested grain. Systematic probing and testing is required to detect infestations early and keep damage to a minimum. Probing costs about .4 cent per bushel of grain. Protectants and fumigants prevent infestation or eliminate insects in the grain. Costs per bushel range from .15 cent for phostoxin pills to .24 for malathion, .4 cent for methyl bromide gas and .5 cent for cyanide gas. The usual price charged by contractors for fumigation is .5 cent per bushel.

Grain samples drawn from elevators in the study over a period of a year indicated substantial success in quality control. But systems vary widely among elevator operators. These variations include much shifting in the use of aeration, protectants and fumigants. The average grade of the grain samples was up slightly at the end of the storage year. Changes in grade from one sample to the next were practically always the result of slight changes in either foreign material or moisture. Mostly the changes were slight and could have been the result of slight variations in the sampling and testing procedures.

implications

Scale of operation has a definite effect on the costs of storing and handling grain. This is particularly true of fixed or ownership costs per bushel. It is not possible to adjust the investment in scales, dumps or pits and grain moving equipment for the wide range in the size of storage units.

Scale also affects variable costs to some extent. Because of the use of larger quantities, the cost per unit of power, fuel and materials such as fumigants tends to be less for the larger elevators. Labor and management can be more specialized and more efficiently used in the larger elevator systems.

The key to low ownership and operating costs is to be found in the original planning and construction of the plant. Some elevators started with just enough storage capacity for merchandising purposes. As production and surplusage of grain increased, the demand for storage increased and additional buildings were added. When not properly engineered and related to the original buildings high costs of operation resulted. This points to the need for careful planning and engineering whether one is building a completely new storage system or making additions to existing storage.

The cost of maintaining the quality or grade of grain in storage is largely determined by the condition of the buildings and by the condition of the grain going into storage. A protectant added as the grain moves into storage is cheap insurance against early infestation by insects.

Aeration is the key to low cost quality maintenance. Aeration removes field and dryer heat and small amounts of moisture and maintains uniform temperatures throughout the grain until it can be properly cooled.

The temperature of the grain should be uniformly lowered as soon as the weather permits to near 40 degrees if possible. This will prevent insect activity.

If grain is properly conditioned and housed, treated with a protectant as it goes into storage and properly aerated, fumigants may be completely avoided or at least reduced to a minimum of one fumigation late in the first year of storage.

As outside temperatures rise the surface of stored grain will become warm and encouraging to insect infestation. This can be counteracted by applying a protectant to the surface and by forced ventilation.

For uniform distribution of air and fumigants, grain should be reasonably free of trash and uniform in depth.

The competitive position of grain storage operators changed substantially from 1962 to 1964. The ratio of off-farm grain stocks to storage capacity declined from the 10-year high of 85 percent on January 1, 1961 to 71 percent on January 1, 1964. This is the same ratio that existed in 1955 when grain stocks and storage capacity were only one-third of the present figures. The effect has been much keener competition for the more limited volume of grain available. Storage operators should expect a continuation and perhaps a worsening of this situation.

Fortunately, much of the storage capacity added since 1955 has been flat storage, some of which may be converted to other uses.

Because of problems relating mainly to climate, the costs of conditioning grain for storage and of maintaining the quality of the grain while in storage is highest in the Coastal Bend area and lowest in the High Plains.

contents

Selected Operating Costs for Storage of Sorghum Grain

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THE PRODUCTION OF GRAIN SORGHUM has increased rapidly in recent years with the development of combine and hybrid varieties and with restrictions on the acreage of cotton and wheat. Sorghum grain has proved to be the most profitable alternative to these two crops. Texas is the leading state in sorghum grain production with almost half of the United States crop. Texas production of sorghum grain increased from about 30 million bushels in the late 1930's to 275 million in the late 1950's but settled back to about 250 million bushels under the feed grain programs of the early 1960's.

Increased production and carry-over have led to large increases in grain storage capacity. Off-farm storage facilities in Texas increased from 105 million bushels in 1945 to 659 million on January 1, 1960 and to 919 million bushels on January 1, 1963. The January 1, 1964 figure of 910 million bushels represents the first decline in storage capacity of record.

The growing importance of sorghum grain in grain storage in Texas is shown in Table 1. It will be noted that the proportion of sorghum grain in off-farm grain stocks increased every year from 1955 when it made up 42 percent of the total to 1964 when it comprised 79 percent. During the same period wheat stocks declined from 55 percent of total off-farm grain stocks to 20 percent.

This does not mean that there was less wheat in storage in 1964 as compared to 1955; actually there were 127 million bushels of wheat in storage January 1, 1964 as compared wtih 118 million on January 1, 1955. However, sorghum grain in off-farm storage increased from 90 million bushels in 1955 to 506 million bushels in 1964. Table 2 shows that off-farm grain stocks accumulated faster than capacity increased from 1955 to 1962 when it began to decrease. By 1964 the percent of capacity in use had dropped to the 1955 level. This is due in part to the feed grain program, and in part to an increase in storage capacity of more than 150 million bushels during 1961. The acreage harvested in 1962 was only 75 percent of the average acreage harvested during the previous 5 years. This decline in off-farm grain stocks relative to grain storage capacity has become a matter of concern to storage operators.

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TABLE 1. PERCENTAGE DISTRIBUTION OF KINDS OF GRAIN IN OFF-FARM GRAIN STOCKS, TEXAS, JANUARY 1, 1955-64[1]

January 1	Sorghum grain	Wheat	Other[2]	Total
		Percent		
1955	42.2	55.0	2.8	100.0
1956	47.0	50.0	3.0	100.0
1957	50.3	47.2	2.5	100.0
1958	64.8	31.6	3.6	100.0
1959	69.8	27.1	3.1	100.0
1960	72.4	26.3	1.3	100.0
1961	73.6	25.4	1.0	100.0
1962	76.0	22.3	1.7	100.0
1963	78.7	20.1	1.2	100.0
1964	78.8	19.8	1.4	100.0

[1]Texas Crop and Livestock Reporting Service.
[2]Corn, oats, barley, rye and soybeans.

These changes in supplies of grain relative to storage capacity has resulted in a growing interest in the cost of grain storage. With large amounts of grain being retained in storage over prolonged periods of time there has developed a special interest in the problem of maintaining the quality of the grain.

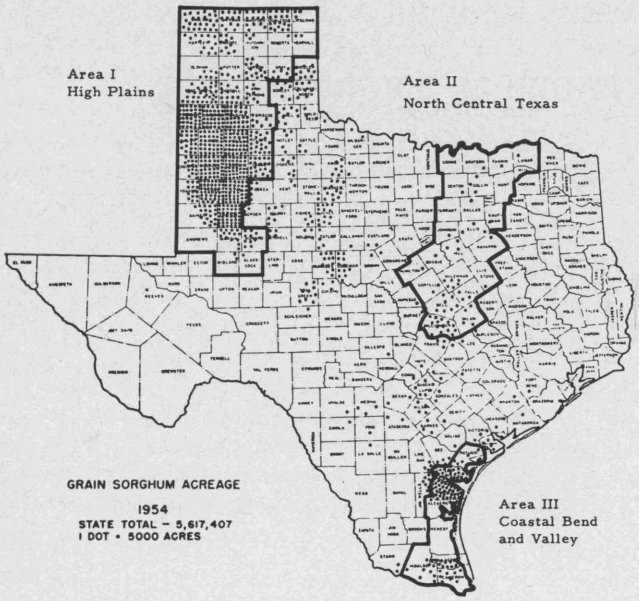
This is one of three studies of the storage and marketing of sorghum grain in Texas. The first study reported in Texas Agricultural Experiment Station Bulletin 997 analyzed and described the marketing patterns and on-farm storage practices of Texas sorghum grain producers. The second, reported in Texas Agricultural Experiment Station Bulletin 996, covered the marketing, storage and handling practices of local commercial storage operators. The current study analyzes some of the problems and costs involved in the management of stored sorghum grain.

Three areas representing more than 80 percent of the state's production of sorghum grain were selected for study. These areas are the High Plains, North Central Texas and the Coastal Bend which for purposes of these studies includes the Lower Rio Grande Valley, Figure 1.

In order that the reader may better understand grain storage problems under widely different conditions and the effect of these differences on costs, a brief description of each area follows.

High Plains

The High Plains produces about two-thirds of the state's sorghum grain crop. Its flat topography and rich soils are well suited to large scale and highly mechanized farming. The elevation ranges from slightly less than 3,000 feet to more than 4,000 feet.



The low average rainfall of less than 20 inches is supplemented to a large extent by irrigation from wells. Temperatures range from hot in summer to cold in winter. Winter temperatures are frequently below zero. The humidity is relatively lower than in the other two areas.

A cropping system of cotton and grain sorghums is dominant on the sandy soils in the southern part of the area. On the clay and clay loam soils of the more northern part of the area where the frost free period is relatively short, wheat and sorghums are practically the only crops grown. Where irrigation is available the two systems overlap on the clay soils in the central part of the area. As restrictions were placed on the acreages of cotton and wheat, the acreage of grain sorghums increased. Over a period of 10 years sorghum grain production increased in this area by more than 100 million bushels. Most sorghum grain is harvested in October and November.

On January 1, 1964 the off-farm grain storage capacity in the High Plains area was 474 million bushels. This was 8 million less than on January 1, 1963 but more than nine times the capacity available in 1949. Also, it is between 2 and 3 times the average annual grain production in the area. A substantial amount of grain from other states is stored temporarily in this area as it moves to the Gulf Coast ports for export.

North Central Area

Most of the grain production in the North Central Area is on Blackland Prairie and on similar soils of the Grand Prairie. Grain sorghums became increasingly competitive with corn in this area with the development of combine and hybrid varieties. Substantial amounts of wheat, oats and barley are produced in the Grand Prairie and in the northern part of the Blackland Prairie.

Compared with the High Plains, the climate is mild. The average annual rainfall will range from 33 inches in the southern part of the area to about 43 inches in the north. Humidity is less of a problem than it is in the Coastal Bend. Temperatures below 50 are uncommon before November, but freezing temperatures are common during December and January. Most sorghum grain is harvested during August and September.

Grain production seldom exceeds 50 million bushels. A part of this production is corn; a large portion of which is stored on the farm. Commercial storage capacity in the area stood at 200 million bushels on January 1, 1964. This is almost 5 times the capacity available in 1949 and about 4 times annual grain production.

Storage operators receive large shipments of grain from other areas for storage. In this area there are many large milling and feed manufacturing companies. Also, it is adjacent to the largest grain-deficit area in the state. These two situations explain much of the demand for grain stored in the area. Over and above these demands some exporting is done.

Coastal Bend

The Coastal Bend like the High Plains is primarily a cash crop area with cotton and sorghum grain accounting for more than 95 percent of all crop sales. A combination of restrictions on cotton acreage and the development of combine and hybrid varieties of sorghums has led to large grain production and storage operations in the area. Where cotton used to occupy more than 80 percent of the cropland, grain sorghums now use about 70 percent of the cropland, while cotton has been reduced to less than 30 percent. Large scale farming is a characteristic of the area. The land is flat and fertile but the lack of good water resources has limited the development of irrigation.

TABLE 2. OFF-FARM GRAIN STORAGE CAPACITY AND STOCKS, TEXAS, JANUARY 1, 1955-64[1]

January 1	Off-farm storage capacity	Off-farm stocks of 7 major grains[2]	Stocks as percent of capacity
	— — Million bushels — —		Percent
1955	300	214	71
1956	320	227	71
1957	360	225	62
1958	390	313	80
1959	567	456	80
1960	659	544	83
1961	760	643	85
1962	915	703	77
1963	919	647	70
1964	910	642	71

[1]Texas Crop and Livestock Reporting Service.
[2]Sorghum grain, corn, wheat, oats, barley, rye and soybeans.

The highest elevation of the area is less than 250 feet. The average annual rainfall ranges from about 20 inches in the more southern and western part to about 36 inches in the north. The combination of low elevation, rainfall and proximity to the coast results in high humidity.

Climatically the Coastal Bend offers the least favorable conditions of the three areas for grain storage. Summer temperatures prevail during about 8 months of the year. It rarely freezes during the winter months and conditions favorable for cooling grain seldom exist before November. Since grain is harvested during June and July new crop grain moving into storage must withstand about 3 months of high temperatures.

Cost-wise this will usually mean more drying and many more hours of aeration than are practiced in the other two areas.

During the late 50's the area was producing about 30 million bushels of sorghum grain. This has been reduced substantially in the 1960's through participation in the feed grain program.

Storage capacity on the other hand has continued to grow. In 1949 the area produced 9 million bushels of grain and had less than 1 million bushels of storage capacity. By 1959 storage capacity had increased to 33 million bushels and by January 1, 1964 to 50 million bushels. Much of the grain produced and stored in this area is eventually exported.

PROCEDURE

Eighteen elevators were selected for more intensive study from among those included in the commercial elevator survey. Originally six were selected from each area, but before the conclusion of the study, one was dropped from the group in the Coastal Bend and two in Central Texas. These elevators were selected to represent different types of operation. A decision to limit the study to 1962 grain affected the selections materially.

During the 1962-63 crop-storage year, these elevators were visited four times. At each visit a sample of grain was obtained for official grading and observations were made of such operations as were underway. During these observations the amounts of labor, power, materials and the volume of grain involved were recorded. Where observations could not be made at the time of the visit, estimates were obtained from elevator personnel. Visits were made to additional elevators to obtain drying costs. At the end of the year, a special survey was made to obtain cost data and to check or test the data obtained by observation. An analysis of these data served as a basis for budgeting costs of the principal functions involved in grain storage operation.

The direct costs of grain storage are classified as (1) ownership or fixed and (2) current operating or variable costs. Fixed costs include depreciation, interest on capital invested, taxes and insurance. Variable costs include electric power, fuel, and direct labor. Administrative costs such as office and management costs are not included here as no good basis could be found for allocating these costs to the various operations. However, a check of some of the more complete elevator records indicates that administrative costs comprise about 30 percent of total variable costs.

Annual ownership costs are considered to be fixed or nonvariable since once the investment is made these costs are incurred regardless of the volume of grain handled. For example, doubling the volume of grain handled would have no effect on the total amount of taxes and insurance paid. However, when costs are figured on a per-bushel basis, fixed costs would vary as the volume of grain handled varied. In other words, if the volume of grain is doubled the per-bushel costs of ownership items are cut in half.

Total variable costs, on the other hand, tend to vary more or less directly with the volume of grain handled in any given situation.

Understanding of the nature of these two groups of direct costs will be further clarified by a study of Tables 3 to 8.

Ownership or Fixed Costs

Fixed or ownership costs of elevator operation include four items: depreciation, interest on money invested, taxes and insurance.

Annual depreciation of ownership items depends on the initial cost of the item and the length of useful life of the item. The range in length of useful life reported as approved by the Internal Revenue Service ranged from 5 to 20 years. However, 15 years was the most common and was adopted for use in this report. The 5-year capital write-off was used as an inducement to expand storage capacity. It affected only a small amount of present storage capacity.

Interest on the investment in ownership items is included as a fixed cost. It is assumed that the money invested in elevator equipment would be earning an amount equal to the interest charged if otherwise invested. The common practice of using the average investment over the life of the ownership item or one-half the initial cost was followed. An annual rate of 5 percent was used to obtain the annual interest charge in each case.

Taxes varied greatly from county to county and from elevator to elevator. This was partly owing to differences in taxing policy and partly to the number of institutions to which the elevator was responsible for taxes. Some elevators were located in open country and not subject to city taxes.

An average tax rate was determined for each of the three areas. This was done by totaling the taxes paid by each group of elevators and by dividing this sum by the sum total of the initial investment in these elevators. The rate thus obtained was applied to the initial cost of the ownership items involved in each of the operations for which fixed costs were computed.

The same method used in allocating the cost of taxes was used in the case of *insurance*. The annual cost of insurance was totaled for the group of elevators studied and this amount divided by the total initial cost of the elevators to obtain a common rate. This was done for each area. It is recognized that this treatment of taxes and insurance is an over-simplification but neither are major cost items.

Variable Costs

The items included in this classification are labor, electric power, fuel and repairs.

The *labor* involved in each operation at each elevator was obtained by observation and by interview and the rate of pay recorded. Representative rates of pay were selected for each area and in turn were adjusted upward to include payroll taxes. This method resulted in an average wage of $1.50 for the High Plains, $1.40 for North Central Texas and $1.35 for the Coastal Bend.

Differences in labor inputs per unit of grain appeared to be more closely related to the size of the operation than to any geographic difference. For the same volume of grain the hours of labor charged to an operation was the same in each area.

The amount of *power* used for a specified quantity of grain for each operation was obtained by observations at most elevators and by interview at others. Since there were no individual meters available for measuring the power used for an individual operation the number and size of motors used and the hours of use were recorded. The total horsepower hours were multiplied by the factor 0.75 to convert horsepower to kilowatt hours used. This factor of 0.75 has been developed and used by engineers in similar studies elsewhere.

The same rates were used to arrive at power costs in all three areas. These rates were based on a study of rate schedules and monthly power bills. The kilowatt hours and dollars involved were tabulated by months and totaled. Total kilowatt hours divided into total dollars gave an average rate for the elevator. In turn, these rates were studied in relation to the volume of grain handled at each elevator. In this way different rates were developed for different levels of operation. Average yearly rates were used because most elevators operated on a power rate schedule with demand charges. Since the seasons of heavy use de-

TABLE 3. BUDGETED DIRECT COSTS OF RECEIVING SORGHUM GRAIN IN LOCAL ELEVATORS, BY AREAS, TEXAS, 1962[1]

Cost item	Direct cost of receiving sorghum grain by volume and area								
	High Plains			North Central			Coastal Bend		
	125,000 bushels	300,000 bushels	600,000 bushels	125,000 bushels	300,000 bushels	600,000 bushels	125,000 bushels	300,000 bushels	600,000 bushels
	Dollars								
Fixed costs:									
Depreciation	1,000	1,200	1,867	1,000	1,200	1,867	1,000	1,200	1,867
Interest	375	450	700	375	450	700	375	450	700
Taxes	72	110	171	111	124	193	117	127	197
Insurance	18	27	41	60	71	110	46	55	86
Total fixed costs	1,465	1,787	2,778	1,546	1,845	2,870	1,558	1,832	2,850
Variable costs:									
Labor	562	1,125	1,800	525	1,050	1,680	506	1,012	1,620
Power	50	105	180	50	105	180	50	105	180
Repairs	188	225	350	188	225	350	188	225	350
Total variable costs	800	1,455	2,330	763	1,280	2,210	744	1,342	2,150
Total fixed and variable costs	2,265	3,242	5,108	2,309	3,125	5,080	2,302	3,174	5,000
	Cents								
Fixed cost per bushel	1.17	.60	.46	1.24	.62	.48	1.25	.61	.48
Variable cost per bushel	.64	.48	.39	.61	.43	.37	.60	.45	.36
Total cost per bushel	1.81	1.08	.85	1.85	1.05	.85	1.85	1.06	.84

[1]Based on these assumptions – initial cost in each area, $15,000 for 125,000 bu., $18,000 for 300,000 bu., $28,000 for 600,000 bu. Power rates at .03 per KWH for large systems, .035 per KWH for medium size systems and .04 per KWH for small systems. Volume received each season estimated at half the capacity of storage units.

termine the demand charges, it was felt that all operations should share equally in the cost.

Natural gas was the only fuel used for drying grain. Several approaches were used in arriving at fuel costs. The amount of fuel used in drying specific quantities of grain was obtained by observation and interview at 15 elevators. Later total costs of fuel and cubic feet of gas used, together with estimates of total bushels of grain dried, were obtained at selected elevators. This information was used in arriving at the amounts of gas used to dry a bushel of grain in each of the three areas. It was also used to arrive at cost rates as affected by the volume of grain dried.

Atmospheric temperatures influence the amount of fuel required. In North Central Texas and the Coastal Bend most grain is dried at summer temperatures. Under these conditions it was estimated that between 2 and 3 percent moisture could be removed from grain with 4 cubic feet of gas per bushel.

On the High Plains where most drying is done at the somewhat lower temperatures prevailing in the fall, it was estimated that 5 cubic feet of gas per bushel of grain would be required to remove 2 to 3 percent of the moisture from grain.

The costs for *repairs and maintenance* are among the most difficult to obtain. Total expenditures for repairs and maintenance for the year 1962-63 for 11 of the cooperating elevators averaged 1.2 percent of the initial cost of the plant. The records did not show how much of the repair cost was spent on the equipment used in the various elevator operations. It was necessary, therefore, to estimate these costs. Owing to differences in the age of the equipment there was considerable difference of opinion as to the amount of repair needed. This was particularly true of aeration equipment only recently added to the elevator system. The amount of repairs varies greatly from year to year. Bearings and gears in grain moving and handling equipment need replacement frequently. Repairs on aeration systems are needed less frequently. After several years the manifold may have rusted out, some of the laterals or air ducts may be damaged in loading out grain or motors may need rewiring. The dryer on the other hand requires little in the way of repairs.

All of the preceding points were considered in arriving at the annual repair costs budgeted to the various elevator operations.

COSTS OF SELECTED OPERATIONS

Most of the 18 storage elevators selected for study had both upright and flat storage. The selection was made difficult by a decision to limit the study to new grain or grain harvested in 1962. Because it is more time consuming and expensive to move grain out of

TABLE 4. BUDGETED DIRECT COSTS OF LOADING OUT SORGHUM GRAIN FROM FLAT STORAGE IN LOCAL ELEVATORS, BY AREAS, TEXAS, 1962[1]

Cost item	Direct cost of loading out sorghum grain by volume and area								
	High Plains			North Central			Coastal Bend		
	125,000 bushels	300,000 bushels	600,000 bushels	125,000 bushels	300,000 bushels	600,000 bushels	125,000 bushels	300,000 bushels	600,000 bushels
	Dollars								
Fixed costs:									
Depreciation	667	800	1,467	667	800	1,467	667	800	1,467
Interest	250	300	550	250	300	550	250	300	550
Taxes	61	73	134	69	83	152	70	84	155
Insurance	15	18	33	39	47	87	31	37	67
Total fixed costs	993	1,191	2,184	1,025	1,230	2,256	1,018	1,221	2,239
Variable costs:									
Labor	579	1,275	2,322	540	1,190	2,167	521	1,148	2,090
Power	71	153	272	71	153	272	71	153	272
Repairs	125	150	275	125	150	275	125	150	275
Total variable costs	775	1,578	2,869	736	1,493	2,714	717	1,451	2,637
Total fixed and variable costs	1,768	2,769	5,053	1,761	2,723	4,970	1,735	2,672	4,876
	Cents								
Fixed cost per bushel	.79	.40	.36	.82	.41	.38	.81	.41	.37
Variable cost per bushel	.62	.53	.48	.59	.50	.45	.57	.48	.43
Total cost per bushel	1.41	.93	.84	1.41	.91	.83	1.38	.89	.81

[1]Based on these assumptions — Initial cost in each area, $10,000 for 125,000 bu., $12,000 for 300,000 bu., $22,000 for 600,000 bu. Power rates at .03 per KWH for large systems, .035 per KWH for medium size systems and .04 per KWH for small systems. Volume loaded out each season estimated at half the capacity of the storage unit.

flat storage, operators tended to hold grain in flat storage and ship out from upright storage. This made it difficult to find new grain in flat storage. The plan was to follow the 1962 crop through a year of storage, recording the preparation for storage and the practices involved in maintaining the quality of the grain while in storage. Very few elevator operators could promise that 1962 grain would be kept in upright storage throughout the year. Also, equipment available was inadequate for sampling grain in tall upright storage. The quality of the grain was checked by official testing of representative samples taken at regular intervals during the year. Samples were taken at the beginning of the year and at the end of the year with two others at approximately 4 month intervals during the year.

Because of difficulties involved in obtaining representative samples from the tall upright storages, most of the data obtained are related to grain in flat storage. For this reason, and unless otherwise indicated, the budgeted costs which follow will represent flat storage only.

Cost of Receiving Grain

With the exception of loading out, the cost of the various operations will be discussed in chronological order starting with the receiving of grain. Harvest is the busiest season of the year for elevator personnel and extra help is usually employed. For the elevators studied, the receiving crew ranged from 3 to 6 men depending somewhat on the size of the operation. On slack days these men may work part time at other jobs.

While there is much variation in the equipment used in receiving grain (described in Texas Agricultural Experiment Station Bulletin No. 996) the basic requirements include the scale, the pit or dump, the elevator and the overhead conveyor or auger. The elevator system must have one or more of each of these items.

The larger elevators, especially if the size is the result of several additions, will have more than one receiving point. In other words they have the equivalent of two or more small systems at one location.

Three sizes of storage units were selected to represent both the single unit elevator and the individual units of the larger elevators. These representative sizes were 250,000, 600,000 and 1,250,000 bushels, respectively.

In budgeting receiving and loading costs it was assumed that half the grain in storage would be moved out to make room for the new crop coming in. For example, for an elevator of 600,000 bushel capacity, it is assumed that 300,000 bushels will be received and an equivalent amount loaded out. This assumption is based on the fact that sorghum grain stocks were slightly more than double average annual production.

In budgeting receiving costs an average day's receipts are assumed. The capacity to receive is substantially greater than average daily receipts. At the peak of the harvest season, however, the facilities may be barely adequate on any given day.

The only part of the grain moving system not used in receiving grain is the lower auger or con-

TABLE 5. BUDGETED DIRECT COSTS OF DRYING SORGHUM GRAIN IN LOCAL ELEVATORS, HIGH PLAINS, TEXAS, 1962[1]

Cost item	Direct cost of drying volumes of sorghum grain									
	25,000 bu.		50,000 bu.		100,000 bu.		200,000 bu.		400,000 bu.	
	Total	Per bu.	Total	Per bu.	Total	Per bu.	Total	Per bu.	Total	Per bu.
	Dollars	Cents	Dollars	Cents	Dollars	Cents	Dollars	Cents	Dollars	Cents
Fixed costs:										
Depreciation	1,400	5.60	1,400	2.80	1,400	1.40	1,400	.70	1,400	.35
Interest	525	2.10	525	1.05	525	.52	525	.26	525	.13
Taxes	128	.51	128	.26	128	.13	128	.06	128	.03
Insurance	31	.12	31	.06	31	.03	31	.02	31	.01
Total fixed costs	2,084	8.33	2,084	4.17	2,084	2.08	2,084	1.04	2,084	.52
Variable costs:										
Labor	38	.15	76	.15	152	.15	304	.15	608	.15
Power[2]	50	.20	100	.20	170	.17	320	.16	600	.15
Repairs	12	.05	25	.05	50	.05	100	.05	200	.05
Fuel[3]	56	.22	105	.21	200	.20	380	.19	760	.19
Total variable costs	156	.62	306	.61	572	.57	1,104	.55	2,168	.54
Total fixed and variable costs	2,240	8.95	2,390	4.78	2,656	2.65	3,188	1.59	4,252	1.06

[1]Based on these assumptions — Power, .04 per KWH through 50,000 bu., .035 per KWH through 100,000 bu., .0325 per KWH through 200,000 bu., and .03 through 400,000 bu.; Gas, .45 per mcf through 25,000 bu., .42 per mcf through 50,000 bu., .40 per mcf through 100,000 bu., and .38 per mcf through 200,000 bu. and above. Moisture removed in drying assumed to be 2-3%.

[2]50 KWH per 1,000 bu.

[3]5 cu. ft. per bu.

veyor. Field dried grain would be moved directly into storage. In some cases grain having less than 15 percent moisture will be moved to storage and aerated immediately and continuously. In one case observed the grain thus treated improved in grade from No. 3 to No. 1.

Grain having 15 percent or more moisture will usually be dried. It may go directly to the dryer or into a special bin or tank and then through the dryer and into storage.

In computing fixed costs for receiving grain into flat storage the estimated initial cost of the pit and half the cost of all other grain moving equipment was charged to receiving and the balance to the loading out operations. In upright storage a share of these costs would also be borne by the turning operation.

As will be noted in Table 3, there is only slight difference in costs of receiving grain among the areas studied. This, of course, is due to the assumption of similar sizes and organization of the units budgeted. The slight differences shown are the result of differences in the cost of such items as taxes, insurance and labor and these tended to offset each other to a large extent. The lower tax and insurance rates in the High Plains area as compared with the other two areas is due to the fact that the majority of the elevators studied on the High Plains were in open country and not subject to city taxes.

It will be noted that while fixed costs per bushel tend to vary inversely with the amount of grain handled, the differences in costs are not proportionate to the differences in the volume of grain. This is because of the difficulties involved in adjusting the investment in grain handling facilities to differences in the size and number of storage units. One scale and dump may be sufficient to serve a wide range in the size and number of storage units but the point is eventually reached where additional facilities such as another elevator or another dump must be added to meet the needs if good service is rendered.

Variable costs per bushel of receiving grain also decrease with an increase in the volume of grain handled but not to the same extent as do fixed costs. While there is a tendency for variable costs to increase directly with increases in the volume of grain handled, in actual practice it is not possible to adjust the labor force in proportion to differences in the volume of grain handled. Furthermore, power costs do not vary directly with changes in volume of grain. While the rate charged for power tends to be less as the quantity used increases, the decrease is never proportionate to the increase in the quantities of power used.

Cost of Loading Out Grain

Loading out grain from flat storage reportedly is more costly than from upright storage. This opinion is supported by the practice of storage operators of retaining grain in flat storage as long as possible. Also, they prefer upright storage for merchandising grain. Grain is moved out of upright storage almost entirely by gravity whereas at least half of the grain in flat storage must be moved into the auger or conveyor manually or with some type of mechanical equipment. This part of the loading out

TABLE 6. BUDGETED DIRECT COSTS OF DRYING SORGHUM GRAIN IN LOCAL ELEVATORS, NORTH CENTRAL, TEXAS, 1962[1]

Cost item	Direct cost of drying volumes of sorghum grain									
	25,000 bu.		50,000 bu.		100,000 bu.		200,000 bu.		400,000 bu.	
	Total	Per bu.	Total	Per bu.	Total	Per bu.	Total	Per bu.	Total	Per bu.
	Dollars	Cents	Dollars	Cents	Dollars	Cents	Dollars	Cents	Dollars	Cents
Fixed costs:										
Depreciation	1,400	5.60	1,400	2.80	1,400	1.40	1,400	.70	1,400	.35
Interest	525	2.10	525	1.05	525	.52	525	.26	525	.13
Taxes	145	.58	145	.29	145	.15	145	.07	145	.04
Insurance	83	.33	83	.16	83	.08	83	.04	83	.02
Total fixed costs	2,153	8.61	2,153	4.30	2,153	2.15	2,153	1.07	2,153	.54
Variable costs:										
Labor	35	.14	70	.14	140	.14	280	.14	560	.14
Power[2]	50	.20	100	.20	170	.17	320	.16	600	.15
Repairs	12	.05	25	.05	50	.05	100	.05	200	.05
Fuel[3]	45	.18	84	.17	160	.16	300	.15	600	.15
Total variable costs	142	.57	279	.56	520	.52	1,000	.50	1,960	.49
Total fixed and variable costs	2,295	9.18	2,432	4.86	2,673	2.67	3,153	1.57	4,113	1.03

[1]Based on these assumptions — Power, .04 per KWH through 50,000 bu., .035 per KWH through 100,000 bu., .0325 per KWH through 200,000 bu., and .03 through 400,000 bu.; Gas, .45 per mcf through 25,000 bu., .42 per mcf through 50,000 bu., .40 per mcf through 100,000 bu., and .38 per mcf through 200,000 bu. and above. Moisture removed in drying assumed to be 2-3%.
[2]50 KWH per 1,000 bu.
[3]4 cu. ft. per bu.

operation is complicated and made more difficult by the presence of air ducts associated with the aeration system. The cost of repairs to the aeration system may be increased through damage to these air ducts while grain is being loaded out of flat storage.

It costs less to load out grain than to receive grain. Less equipment is involved and consequently less power is used. However, somewhat more labor is required for loading out grain from flat storage than is used in receiving grain. The net effect of these differences is seen in Table 4. It will be noted that in general, costs of loading out grain behave in a manner similar to the costs of receiving grain. The narrowing of the spread in costs as affected by the volume of grain handled is found partly in the difference in the relationship of capital costs to volume of grain and partly to the larger place of labor in the variable costs of loading out grain.

The costs per bushel for both receiving and loading out grain would be lower or higher than those shown in Tables 3 and 4 assuming larger or smaller proportions of the capacity received or loaded out. The resulting difference would be largely the effect of spreading ownership or fixed costs over larger or smaller volumes of grain.

Cost of Drying Grain

The practice of harvesting sorghum grain before the moisture content reaches safe storage levels in the field is a growing problem for storage operators. Researchers have developed evidence that the quality of grain is enhanced if harvested before it is fully field dried. Also, field losses from shattering, weather and insect damage are reduced through less exposure in the field.

Several methods of meeting this problem have been developed. When the excess of moisture is slight it may be blended with dry grain to reduce the moisture content to the safe 13 percent storage level. Some storage operators place grain of less than 15 percent moisture in flat storage and aerate continuously until the moisture content reaches the safe storage level.

The more common practice is to reduce the moisture content of the grain by artificial drying. A survey made in the winter of 1960-61 indicates that artificial drying of sorghum grain had its beginning on the High Plains and in North Central Texas during the past 10 years (1953-63). Humidity runs high in the Coastal Bend and the danger of field losses from tropical storms is always a concern of producers. There is little risk involved from field drying in North Central Texas but the short growing season in the High Plains area means slow maturity of the grain crop in most years. Late-planted grain may be left in the field until frost hastens its maturity.

In the above-mentioned survey, it was found that in the Coastal Bend 70 percent of the storage operators dried three-fourths of the grain received for storage and none of them dried less than one-fourth. At the same time only 11 percent on the High Plains and none in North Central Texas dried as much as three-fourths of the grain stored. However, about three-fourths of the operators on the High Plains and less than one-fifth of them in North Central Texas dried some of the grain received for storage.

TABLE 7. BUDGETED DIRECT COSTS OF DRYING SORGHUM GRAIN IN LOCAL ELEVATORS, COASTAL BEND, TEXAS, 1962[1]

Cost item	Direct cost of drying volumes of sorghum grain									
	25,000 bu.		50,000 bu.		100,000 bu.		200,000 bu.		400,000 bu.	
	Total	Per bu.	Total	Per bu.	Total	Per bu.	Total	Per bu.	Total	Per bu.
	Dollars	Cents	Dollars	Cents	Dollars	Cents	Dollars	Cents	Dollars	Cents
Fixed costs:										
Depreciation	1,400	5.60	1,400	2.80	1,400	1.40	1,400	.70	1,400	.35
Interest	525	2.10	525	1.05	525	.52	525	.26	525	.13
Taxes	148	.59	148	.30	148	.15	148	.07	148	.04
Insurance	64	.26	64	.13	64	.06	64	.03	64	.02
Total fixed costs	2,137	8.55	2,137	4.28	2,137	2.13	2,137	1.06	2,137	.54
Variable costs:										
Labor	34	.14	68	.14	135	.14	270	.14	540	.14
Power[2]	50	.20	100	.20	170	.17	320	.16	600	.15
Repairs	12	.05	25	.05	50	.05	100	.05	200	.05
Fuel[3]	45	.18	84	.17	160	.16	300	.15	600	.15
Total variable costs	141	.57	277	.56	515	.52	990	.50	1,940	.49
Total fixed and variable costs	2,278	9.12	2,414	4.84	2,652	2.65	3,127	1.56	4,077	1.03

[1]Based on these assumptions — Power, .04 per KWH through 50,000 bu., .035 per KWH through 100,000 bu., .0325 per KWH through 200,000 bu., and .03 through 400,000 bu.; Gas, .45 per mcf through 25,000 bu., .42 per mcf through 50,000 bu., .40 per mcf through 100,000 bu., and .38 per mcf through 200,000 bu. and above. Moisture removed in drying assumed to be 2-3%.
[2]50 KWH per 1,000 bu.
[3]4 cu. ft. per bu.

The amount of grain requiring drying varies greatly from year to year and from one part of the state to another. For example, a minimum amount of grain required drying in 1962 in all of the areas studied. In 1963, however, a large part of the crop produced in the Coastal Bend needed drying and some of it contained excessive amounts of moisture. One operator reported grain with moisture content as high as 29 percent. Drouth had resulted in weak sorghum stalks and excessive loss from heavy rain or tropical storms was feared. No similar situation existed in the other areas.

When grain is received at the elevator, it is tested for moisture and moved into storage or into temporary storage depending upon its moisture content. Most elevators have what they call their wet tank where "wet" grain is stored while it awaits drying. In situations where grain is being received in amounts substantially in excess of the dryer capacity the tanks may be aerated to keep down molds and other forms of spoilage until the grain can be dried.

When the moisture content of the grain is excessive it may be passed through the dryer 2 or 3 times in order to bring the moisture content to safe storage levels. One operator dries wet grain to 15 percent as quickly as possible, then moves it into upright storage from which it will be dried to 13 percent after harvest.

The cost of drying grain varies with the size of the dryer, the amount of moisture to be removed and with the volume of grain dried. The data available were insufficient for evaluating the effects of size of dryer and moisture content on drying costs. The budgeted cost in Tables 5-7 show how volume of grain dried affects drying costs when 2 to 3 percent moisture is removed in a continuous flow dryer. With volumes ranging from 25,000 to 400,000 bushels the direct cost of drying ranged from about 9 cents to slightly more than 1 cent per bushel. Fixed costs made up largely of depreciation and interest on the capital invested in the dryer, account for most of the difference.

Variable costs on the other hand tend to vary directly with volume and only account for a small part of the change in the cost per bushel with the increase in the volume of grain dried. The slight difference of .08 of a cent per bushel in the variable cost of drying 25,000 or 400,000 bushels is the result of differences in the rates that would be paid for power and fuel when such widely different quantities of grain are dried.

COST OF MAINTAINING THE GRADE OF GRAIN IN STORAGE

The principal concern in this phase of the study is in the problems involved in preserving the grade

TABLE 8. BUDGETED DIRECT COSTS OF AERATION OF SORGHUM GRAIN IN LOCAL ELEVATORS, BY AREAS, TEXAS, 1962[1]

Cost item	Direct cost of aeration of sorghum grain by volume and area								
	High Plains			North Central			Coastal Bend		
	250,000 bushels	600,000 bushels	1,250,000 bushels	250,000 bushels	600,000 bushels	1,250,000 bushels	250,000 bushels	600,000 bushels	1,250,000 bushels
	Dollars								
Fixed costs:									
Depreciation	333	800	1,667	333	800	1,667	333	800	1,667
Interest	125	300	625	125	300	625	125	300	625
Taxes	24	58	121	37	88	185	39	94	195
Insurance	6	14	29	20	48	100	22	52	108
Total fixed costs	488	1,172	2,442	515	1,236	2,577	519	1,246	2,595
Variable costs:									
Labor	27	36	45	25	34	42	24	32	40
Power	300	630	1,125	638	1,338	2,390	1,012	2,126	3,797
Repairs	50	120	250	62	150	312	75	180	375
Total variable costs	377	786	1,420	744	1,522	2,744	1,111	2,338	4,212
Total fixed and variable costs	865	1,958	3,862	1,239	2,758	5,321	1,630	3,584	6,807
	Cents								
Fixed cost per bushel	.20	.20	.20	.20	.21	.21	.21	.21	.20
Variable cost per bushel	.15	.13	.11	.30	.25	.22	.44	.39	.34
Total cost per bushel	.35	.33	.31	.50	.46	.43	.65	.60	.54

[1]Based on these accumptions — Initial cost in each area — $5,000 for 250,000 bu., $12,000 for 600,000 bu. and $25,000 for 1,250,000 bu. Power rates at .03 per KWH for large systems, .035 per KWH for medium size systems and .04 per KWH for small systems. Repairs are related to hours of use, High Plains 400 hours, North Central 850 hours and Coastal Bend 1,350 hours.

or quality of the grain while in storage. Grade maintenance has always been a problem in grain storage but it has increased as the accumulation of grain stocks has lengthened the storage period. In recent years large quantities of grain have remained in storage for two or more years. Prior to the surplus problem most storage was upright and local storage was used primarily for merchandising purposes. In other words, the length of the storage period was relatively short. With upright storage the grain could be turned or moved from one bin to another at which time it could be thoroughly inspected, treated for insect control and uniformly cooled. The great increase in the need for storage led to the construction of many flat storage buildings. The extent of the shift in emphasis from upright to flat storage is illustrated in data on storage space collected during the second phase of this study.[1] Prior to 1956, 67 percent of the available storage was upright, but from 1956 to 1960, inclusive, available storage space in Texas more than doubled. Eighty percent of the new construction was flat storage, thus bringing flat storage to about 57 percent of all available storage at that time. This trend to flat storage is largely due to less costly and more rapid construction. Also it is more easily adapted to other uses should the future demand for storage space for grain decline. It would be very expensive to turn grain in flat storage but it is well adapted to aeration.

Grade maintenance is largely a matter of controlling moisture, temperature and insects. The problem of control is simplified by good preparation before the grain goes into storage. Clean, dry grain is easily managed in buildings that are tight and clean.

In flat storage grade maintenance depends largely on aeration and insect control.

Cost of Aeration

In 1960, two-thirds of all storage space on the High Plains and four-fifths of the space in the other two areas was equipped with aeration. More has been added since. Practically all flat storage is presently equipped with aeration. Aeration is being added to upright storage more gradually, probably because of the alternative of turning.

Aeration has become the key operation in quality maintenance. It is used (1) to remove harvest or dryer heat; (2) to prevent molds and heating in wet grain prior to drying; (3) to remove small amounts of moisture; and (4) to maintain the quality of grain during storage. The aeration system, also, is used to distribute fumigants uniformly in stored grain.

When the aeration system is properly engineered or fitted to the storage unit there is very little difference in the capital investment in equipment per bushel of grain. Consequently, there is very little difference in fixed or ownership costs per bushel. This is one of the assumptions in the budgeted costs shown in Table 8. There are slight differences in costs from area to area because of slight differences in taxes and insurance in the case of fixed costs and in wages and repairs in the case of variable costs. Most of the difference in costs from area to area relate to differences in hours of operation. Hours of operation in turn are related to differences in weather conditions during and following harvest.

In the High Plains area most sorghum grain is harvested in October and November when there is little danger from harvest heat and the process of reducing grain temperatures to desired storage levels can be started very soon if not immediately, Table 9. Under these conditions the objective is reached in a comparatively short period of time.

There were six cases studied in the High Plains. In each case aeration was applied intermittently to equalize grain temperatures within the bin and reduce temperatures to desired levels. No aeration was performed at any elevator after March of the storage year studied.

At four of the six elevators, the sorghums were aerated an average of about 250 hours each. Two elevators aerated more than 500 hours. The grain with the most aeration did not attain a higher market value than the lesser aerated sorghums so that the cost of the additional aeration was an unnecessary expense.

There was a slight to moderate moisture build-up in the spring and summer months of 1963 when there was no aeration. At two elevators, the build-up was enough to reduce grade. There was little or no change in damage content during the storage year.

In the North Central area, sorghum is harvested in August and September. Temperatures are high, but the period until cooler temperatures prevail is not long. Five cases were observed in this area. Moisture content of the lots observed was unusually low when the sorghums moved into storage. The range was from 10.6 to 12.4 percent. Aeration was started as soon as the sorghums were binned but the individual operators followed no pattern as to the amount of continuous and intermittent aeration performed, the total number of hours of aeration, or the length of time intermittent aeration was continued. Total number of hours of aeration ranged from 225 to 1690. Two operators did not aerate after January, while three aerated a small number of hours in the spring of 1963.

Two operators aerated a total of less than 400 hours; two others operated between 800 and 1000 hours. While the sorghums aerated less than 400 hours maintained market grade as well as those aerated 800-1000 hours, the lesser amount is not recommended because the sorghums were unusually dry when stored. In other years, with different

[1]Texas Agricultural Experiment Station Bulletin 996.

climatic conditions and higher moisture contents, 400 hours of aeration might not be sufficient.

In the Coastal Bend most sorghums are harvested in July when summer temperatures are nearing their peak. Also, sorghums are normally harvested at a higher moisture content than in the other areas. Of the four cases observed all sorghums were above 13.0 percent moisture, the maximum content for No. 1. Aeration is most important in this area, since it inhibits mold growth to some extent and also removes small amounts of moisture. In each of the cases studied enough moisture was removed to improve the grade from No. 2 to No. 1 on that factor.

Aeration is started when the grain is binned and is applied continuously for more than a month. Then the grain is aerated part of each day until it approaches outside temperatures of 40 to 50 degrees which usually occur sometime in December. From December until May the bins received an average of an additional 120 hours of aeration. A total of 1350 hours aeration was budgeted for this area. It is probable that most sorghums can be stored in the Coastal Bend with less aeration but in a hot humid climate the risk is great and the small additional cost is good insurance.

It was assumed in the budgeted costs in Table 8 that 400 hours of aeration would be adequate in the High Plains area while 850 hours and 1,350 hours would serve the needs in North Central Texas and the Coastal Bend, respectively. In actual practice, of course, there are wide differences in the hours of operation of the aeration system from storage to storage. Among cooperating elevators in 1962 the range was from 240 to 528 hours for flat storage on the High Plains, 225 to 1,690 hours in the North Central area and from 808 to 1,820 hours in the Coastal Bend area.

Some of the variation in the hours of operation of the aeration systems is owing to the broader uses made of the system by some operators. If the system is used to remove some of the moisture content of the grain and to maintain the quality of the grain during the warm part of the season many more hours of operation are needed than is required when operation is limited to periods when temperatures are favorable to cooling. It may also be caused by the degree of control exercised. Most of the smaller systems are manually controlled which means that the operation may not be synchronized with changes in temperature. Some of the larger systems are automatically controlled and are in operation only when the temperature and humidity are favorable for efficient operation.

Cost of Turning Grain

The basic operation for quality maintenance in upright storage is turning. For example, grain is moved from one bin to another with the grain moving equipment. Currently all upright storage not equipped with aeration will turn stored grain from 1 to 4 times during the year. Even after adding aeration equipment some operators may continue to turn occasionally. The turning operation provides the opportunity to thoroughly inspect the grain, equalize the temperature and treat the grain with a protectant. Some operators provide more cooling to the operation by passing the grain through the dryer in the process of turning. This is done without heat and with both the hot and cool fan in operation.

TABLE 9. TEMPERATURES DURING SORGHUM GRAIN HARVEST AND NORMAL AERATION PERIODS, BY AREAS, TEXAS, 1962-63

Area	Month	Temperatures				
		Minimum	Maximum	Average minimum	Average maximum	Average temperature
Coastal Bend[1]	July	72	103	75.1	96.8	86.0
	August	72	109	76.4	100.0	88.2
	September	65	98	74.2	93.0	83.6
	October	50	99	68.8	90.9	79.9
	November	42	90	53.8	77.3	65.5
	December	33	81	46.7	65.3	56.0
	January	18	87	38.3	60.6	49.5
North Central[2]	August	70	108	75.8	100.1	88.0
	September	57	98	69.9	90.8	80.4
	October	45	93	62.3	82.2	72.3
	November	35	86	47.8	67.8	57.8
	December	22	74	39.1	59.1	49.1
	January	14	80	29.8	51.9	40.9
High Plains[3]	September	44	94	57.1	81.3	69.2
	October	37	90	45.7	75.8	60.8
	November	28	80	35.4	62.9	49.2
	December	12	76	27.6	55.1	41.4
	January	—6	74	12.9	49.2	31.1

[1]Robstown [2]Waco [3]Plainview

Although this study did not provide sufficient data to permit an analysis of the costs of managing grain in upright storage, the following single example of the cost of turning may throw some light on this subject and more especially on the problems and costs of quality maintenance. The basic equipment used in turning are the upper and lower augers or conveyors and the elevators. Since this same equipment is used, also, in receiving grain, in loading out grain and in moving grain to and from the dryer, the fixed costs involved must be divided among these operations. In Table 10, the fixed costs are allocated to turning based on estimates of the proportionate use made of the grain moving equipment by these operations.

Cost of Insect Control

If aeration is the key to quality control, insects are the core of the problem. Insect control is a matter of primary concern to all storage operators. The primary purpose of cooling grain to low temperatures is to create an unfavorable environment for insects. Under favorable conditions very little more than aeration may be needed. However, poorly designed aeration, trashy grain and grain of different depths in the same bin may result in poor distribution of air, uneven cooling, moisture migration and moldy, insect-infested grain.

Despite the best that can be done with aeration some difficulty with insects may be expected and most storage operators are constantly alert in anticipation of trouble. Systematic probing and testing is a must if infestations are to be detected early and damage kept at a minimum. An abnormal rise in temperature in some part or parts of the bin is a common signal that insects are at work. Some of the larger storage systems are equipped with automatic temperature sensing systems. But most storage operators use some type of probe thermometer as did all of those that cooperated in this study. Probing is laborious, time consuming and easily neglected. But if it is to serve its purpose it must be done frequently and systematically. Some operators prepare a chart for each building showing the locations of each probe for which the temperatures are to be recorded each time. A thorough job of probing with a vacuum type probe will require between 2 and 3 hours of labor per 1,000 bushels of grain per year and with the costs of the probe included would cost about .4 cents per bushel of grain in storage.

The job of controlling insects begins with prevention. When bins are emptied they are thoroughly cleaned and disinfected before refilling. The area surrounding the bins is kept clean and sprayed to keep down migration.

A protectant can be applied when grain is being put into storage or when as in case of upright storage it is being turned. In either case malathion mixed

TABLE 10. DIRECT COST OF TURNING GRAIN IN ONE ELEVATOR, TEXAS, 1962

Cost item	Times grain is turned[1]			
	1	2	3	4
	Dollars			
Fixed costs:[2]				
Depreciation	533	800	960	1,067
Interest	200	300	360	400
Taxes	56	85	91	101
Insurance	25	37	40	44
Total fixed costs	814	1,222	1,451	1,612
Variable cost:				
Labor	564	1,128	1,692	2,256
Power	209	418	627	836
Repairs	180	270	292	324
Total variable costs	953	1,816	2,611	3,416
Total fixed and variable costs	1,767	3,038	4,062	5,028
	Cents			
Total fixed and variable cost per bushel	.51	.87	1.17	1.44

[1]Number bushels turned is 348,000 bushels for each turning.
[2]Based on estimates of proportionate use of grain moving equipment for receiving, loading out, moving grain to and from the dryer and for turning 1 to 4 times.

with water at the rate of 3 gallons to 52 gallons of water is sprayed into the upper auger as the grain moves into storage. Calibrated nozzles are used to regulate the amount of insecticide. As little as 1 pint per 1,000 bushels is used but 2 pints is more common. It will be noted from Table 11 that the budgeted cost of this protectant is less than ¼ cent per bushel. It is claimed that the effects of malathion applied as a protectant will last from 6-9 months. However, 5 of 7 elevators that used a protectant also fumigated once. On the other hand 7 of 8 elevators that did not apply a protectant fumigated twice, see Table 12.

Malathion is also used for top-dressing grain in storage. In most instances the same mixture is used. It is sprayed on the surface from where it gravitates into the top 3 to 4 feet of the grain. Normally the cost is less than .01 cent per bushel. In the Coastal Bend most storage operators mix the malathion with an oil which is designed to seal the surface of the grain and serve as a repellent. It is about twice as expensive as when it is mixed with water.

The use of protectants is more common on the High Plains than in the other two areas.

When grain in flat storage becomes infested, fumigation is indicated. Fumigants most commonly used were Methyl Bromide, Cynogas and Phostoxin pills. A liquid fumigant (80 percent carbon tetrachloride and 20 percent carbon disulfide) is used to some extent. It is usually applied to the surface of the grain to gravitate through the mass. However, there was insufficient observation of this fumigant to permit a cost analysis.

Most commonly used were Synogas and Methylbromide, both applied through the aeration system. Both are passed through the grain in the form of gas. To be most effective the storage building must be tightly sealed and the gas uniformly spread throughout the grain mass. Most aeration systems are designed to permit recirculation of the gas but a single treatment is not uncommon. After fumigation the building is usually kept sealed for about 30 days after which the aeration system is operated for 6 to 8 hours to clear out the gas. Great caution is indicated in the use of gas forming fumigants. Carelessness could lead to asphyxiation. To avoid the risk, some operators contract the fumigation of their grain to specialists.

There is a difference of about one-tenth of a cent per bushel in the cost of fumigation when these two fumigants are applied through the aeration system, Table 11. The difference is due solely to the difference in the cost of the fumigants. An almost standard price charged for fumigation by contractors was one-half cent per bushel.

Another fumigant which seems to be increasing in popularity is phostoxin. It comes in the form of pills which slowly form a gas when exposed to air. It takes about four hours for complete transformation. This fumigant is applied by spreading pills over the surface of the grain and by systematically probing them into the grain at different levels. The use of this method varies from complete dependence upon it to spot treatments. Here again grain bins need to be tightly sealed to insure effective use. The popularity of this fumigant is due in part at least to the relatively low cost of about .15 cent per bushel of grain treated, Table 11.

SYSTEMS OF QUALITY CONTROL

There are no set systems of quality control. Most storage operators vary their practices with the need and with their experience. There is much shifting within the year in the use of fumigants. The use of aeration ranges widely among storage systems. These variations may be explained in terms of experience of the operators, efforts to adjust to changes in the problems involved and to the desire on the part of the operators for more effective controls. Condition of the grain going into storage as well as the condition of the storage buildings may be involved, also.

Grades were obtained on samples of 1962 grain from 15 of the 18 cooperating storage systems. The samples were drawn from each mass of grain studied in the following manner. In each flat storage building, four or five positions were selected and charted so that they could be readily located each time a sample was taken. Three probes were made at each position and at three different depths. The depth intervals varied with the depth of the grain. The samples were drawn from the same positions and depths each time. No surface samples were taken. These 12 to 15 samples were placed in a bucket and thoroughly mixed to produce a composite sample. A part of the sample was placed in a cellophane bag to protect its moisture content, and it in turn was placed in a canvas bag with the rest of the sample. Each sample thus drawn was sent to the Inspection Office of the Grain Division of the Agricultural Marketing Service and tested for weight per bushel, moisture, damaged kernels and foreign material.

The same procedure was followed for upright storage except that five or six probes were made at only two positions.

All of the grain sampled was aerated to some extent. On the High Plains two out of six storage systems applied a protectant as the grain went into storage and aerated it, Table 12. One of them topdressed the grain once. This represented the minimum of quality maintenance treatment. Both started with No. 2 grain and ended the year with No. 1 grain.

Two other High Plains storage systems aerated, used a protectant, fumigated once and top dressed.

TABLE 11. COST OF TREATMENT OF GRAIN SORGHUM FOR INSECT CONTROL IN LOCAL ELEVATORS, TEXAS, 1962[1]

Method of insect control	Quantity of chemical used per 1000 bushels		Cost of chemical		Amount of labor per 1000 bushels	Cost of labor	Cost of power	Total cost	
			Per unit	Per 1000 bushels		Per 1000 bushels	Per 1000 bushels	Per 1000 bushels	Per bu.
	Unit	Number	— — Dollars — —		Hours	— — — — Dollars — — — —			Cents
Malathion applied at time of storage or while turning grain	Quart	1	2.13	2.13	.05	.08	.20	2.41	.24
Gas applied through aeration system:									
Cyanide (HCN)	Pound	5	.85	4.25	.24	.36	.34	4.95	.50
Methyl bromide	Pound	5	.65	3.25	.24	.36	.34	3.95	.40
Phostoxin pills probed into grain	Pill	12	.08	.96	.35	.50	.00	1.46	.15

[1]The usual custom rate for applying gas through the aeration system was .5 cents per bushel.

Grain from both graded No. 1 at the beginning of storage and No. 2 at the year's end.

A third pair did not apply a protectant but fumigated twice and did not top-dress. One's grain graded No. 1 throughout the year while the other's grain dropped from No. 1 at the beginning to No. 2 at the end of the year.

Using the budgeted costs in Tables 8 and 11 and adding .4 cent for probing and testing the total cost of quality maintenance would be 1.0 cent per bushel for the first pair, 1.4 cents for the second pair and 1.55 cents for the third pair.

In North Central Texas all samples graded No. 2 throughout the year in each case. As to quality maintenance practices, one used a protectant, aerated and fumigated once. His costs were 1.22 cents per bushel. Three others aerated, fumigated twice and top-dressed. Their budgeted costs for quality maintenance were 1.55 cents.

In the Coastal Bend three sets of samples came from flat storage and two from upright storage. One flat storage system aerated, fumigated once and top-dressed. The grain graded No. 3 at the beginning of the year and No. 1 at the year's end. The cost of maintaining quality in this case would be about 1.4 cents per bushel. This same grain was put in storage with the moisture content between 14 and 15 percent. The moisture was reduced by aeration.

Two other flat storages aerated, fumigated twice and top-dressed. The first samples graded No. 2. At the year's end one was still No. 2 while the other graded No. 1. The cost based on Tables 8 and 11 would be 1.80 cents per bushel.

Of the two upright storage systems, both aerated lightly, put on a protectant, fumigated once and top-dressed. One turned grain once and the other twice. In both cases the protectant was applied in the turning operation. They both started and ended the year with No. 2 grain. The estimated costs based on Tables 8 and 9 are 1.99 cents per bushel for the former and 2.42 cents for the latter. If the latter had used a protectant on the second turning rather than fumigating the cost of all quality control operations would have been 2.26 cents instead of 2.42 cents.

Since many systems were used and many variables were encountered, it is difficult to evaluate specific procedures. However, certain tentative conclusions can be drawn:

1. In all cases but one, the average increase in damage was less than one half of one percent during the storage year. The one lot that was an exception increased in damage from none at the time the sorghums were moved into storage to 5.0 percent after one year.

2. All of the combinations of protectants, fumigation and top dressing were reasonably effective. Only one storage developed an insect infestation.

3. A protectant applied at time of storage plus one fumigation is usually all that is needed. If insects appear after the fumigation they can usually be eliminated by spot fumigation with phostoxin at a low cost.

4. A protectant of malathion is recommended because of low cost and has the added advantage of being applied with little extra labor or time during the storing operation.

TABLE 12. QUALITY MAINTENANCE SYSTEMS AND RESULTING GRADES OF SORGHUM GRAIN IN LOCAL ELEVATORS, TEXAS, 1962-63

Area	Operation performed					Samples[1]				Cause of grade change[3]
	Aeration	Protectant	Fumigation	Turning	Top dress	1st	2nd	3rd	4th[2]	
						Grades				
	Times Performed									
High Plains	1	1	0	0	1	2	1	1	1	FM
	1	0	2	0	0	1	1	2	2	W
	1	0	2	0	0	1	1	1	1	
	1	1	1	0	1	1	2	2	2	FM
	1	1	1	0	3	1	1	2	2	M
	1	1	0	0	0	2	1	1	1	FM
North Central	1	0	2	0	3	2	2	2	2	
	1	0	2	0	1	2	2	2	2	
	1	1	1	0	0	2	2	2	2	
	1	0	2	0	0	2	2	2	2	
Coastal Bend	1	0	1	0	1	3	2	1	1	M & FM
	1	0	2	0	1	2	2	2	1	M
	1	0	2	0	0	2	3	3	2	M & FM
	1	1	1	1	1	2	2	2	2	
	1	1	1	2	1	2	1	2	2	FM

[1]Grades by Federal Grain Inspection Service, Fort Worth, Texas.
[2]In 5 cases grain had been sold or moved – grade obtained from elevator manager.
[3]M = Moisture, W= Weight per bushel, FM = Foreign matter.

5. In the High Plains and North Central Areas it is recommended that the sorghums be watched closely for moisture build-up during the spring and summer months.

6. Reducing moisture to a point below 13 percent is essential as a preventative to spoilage of the grain and as a deterrent to insects.

7. There is little or no economic advantage in raising the grade of the sorghums from either No. 3 or No. 2 to No. 1 on the moisture factor because any increase in price received for No. 1 sorghums is approximately cancelled by the loss in weight due to moisture reduction.

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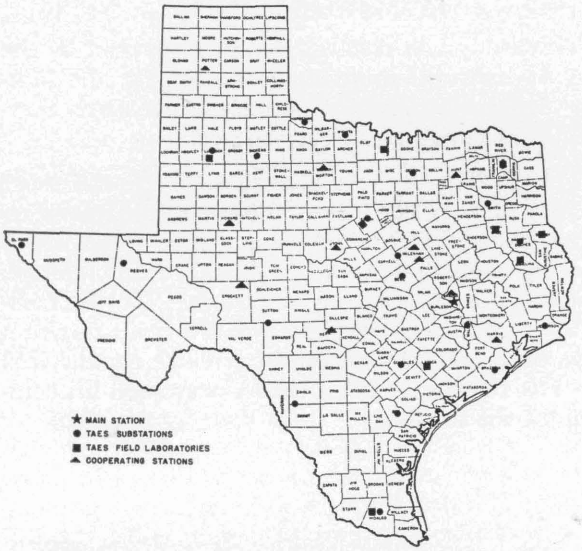

Location of field research units of the Texas Agricultural Experiment Station and cooperating agencies

State-wide Research

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IN THE MAIN STATION, with headquarters at College Station, are 13 subject-matter departments, 3 service departments, 3 regulatory services and the administrative staff. Located out in the major agricultural areas of Texas are 20 substations and 10 field laboratories. In addition, there are 13 cooperating stations owned by other agencies. Cooperating agencies include the Texas Forest Service, Game and Fish Commission of Texas, Texas Prison System, U. S. Department of Agriculture, University of Texas, Texas Technological College, Texas College of Arts and Industries and the King Ranch. Some experiments are conducted on farms and ranches and in rural homes.

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- Fruits and nuts
- Oil seed crops
- Ornamental plants
- Brush and weeds
- Insects
- Beef cattle
- Dairy cattle
- Sheep and goats
- Swine
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- Rural agricultural economics
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