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Drying Shelled Corn

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Summary and Conclusions

Shelled-corn-drying tests were conducted at Caldwell, Idaho with heated and unheated air. Weather data involving temperature, relative humidity, and wet-bulb depression was gathered for an 18-year period. Regression curves were drawn showing the expected drying conditions for each week of the drying period.

From the test results and the analysis of weather data, curves relating air-flow rate, drying conditions, crop moisture content, and drying time were drawn. The operating costs for several sizes of drying units were recorded and the results presented in charts and tables. Cost estimates of the drying equipment were made. A comparison of the total drying cost for unheated-air and heated-air drying was made.

Both unheated-air drying and heated-air drying are highly dependent on natural drying conditions. The air-flow rate must be high enough to dry the corn in 15 days or before mold damage develops. High air-flow rates are not economical when drying in deep layers. The most satisfactory and economical design provides 5 cfm per bushel.

Unheated air will be the most economical drying method; however, unheated air can be relied on for drying only in October and early November. An LP-gas heater will allow drying in almost any weather. If more than one batch is to be dried per season with the same unit, then a heater should be used.

Power costs for drying with unheated air will be about 2 cents per bushel. Power and fuel costs, when using heated air, will be about 3 cents per bushel. The total cost for 1 batch per year will range from 15 cents to 20 cents per bushel using unheated air and 20 cents to 25 cents using heated air. The use of heated air may allow an additional batch to be dried thus reducing the total cost to 10-15 cents per bushel.

Drying Shelled Corn

Larry G. Williams and J. W. Martin*

The development of higher yielding, early maturing varieties of corn has made it possible for Idaho growers to raise quality corn in competition with the Midwest if the grain can be dried to a safe moisture content. In 1958 Idaho imported more than 500 carloads of corn for livestock and poultry rations. Due to the freight rate, Idaho growers have a margin of 60 cents per bushel over Midwest corn. There is also a potential market in California for corn dried to an acceptably low moisture content.

Growers have the choice of drying shelled corn by one of two methods—batch drying or deep-bin drying. The batch dryer forces air which has been heated to a high temperature through a layer of corn 18 inches deep. The drying time varies from 1 to 3 hours. The grain is usually circulated through the dryer for uniform drying. The batch-type dryer has the ability to dry the crop in any weather and at a rate about equal to the rate of harvesting. The greatest disadvantage of the batch dryer is its high initial cost. Fuel costs are also higher than for other methods.

Deep-bin drying means drying the grain in large bins at depths from 4 to 8 feet. The drying bin is usually used as the storage bin. This method requires a drying time from 3 days to a month. The advantage of this system is its low initial cost and low drying cost. The disadvantages of the deep-bin method are less capacity per fan horsepower and the slow drying rate. Less fan capacity is available due to the higher static head required to force the air through the grain. If unheated air is used, drying depends on weather conditions. The air can be heated 10° to 20°F. to improve natural drying conditions. This is known as heated-air drying. The cost of the heater is relatively low and drying can be done in almost any weather condition with reasonably low fuel costs.

Of Idaho's grain-corn-producing farms, approximately 85 percent grow 20 acres or less. These growers cannot justify a batch dryer for this acreage unless they do custom work to reduce expenses. The 85 percent of the farmers who grow corn on less than 20 acres will have a total yield of less than 2000 bushels. This quantity can be dried at one time with a 5-horsepower unit in a suitable drying bin. Therefore, deep-bin drying will probably be best for these growers. The research work reported here has been confined to drying in deep bins.

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purpose of the study

Drying tests were conducted on 14 batches of shelled corn representing about 13,000 bushels. The corn was dried in 1,000-bushel steel bins in depths from about 4 to 8 feet using unheated air and heated air. Weather data for an 18-year period was obtained from the United States Weather Bureau at Boise, and statistically analyzed to determine the drying conditions that can be expected in the Boise Valley corn-growing area. The specific objectives of this bulletin are:

1. To present a summary of expected natural drying conditions from a statistical analysis of weather conditions.
2. To relate climatological information from the statistical analysis to the variables involved, and give recommendations regarding air-flow rates and drying time.
3. To present results of field tests in terms of expected drying time and drying costs.

theory of drying

Drying corn with unheated or heated air involves several variables. These variables include moisture content of the corn entering the bin, temperature and relative humidity of the drying air, and air-flow rate per bushel of corn.

Moisture is removed by passing dry air through the grain. The grain which first comes into contact with the drying air will dry first. As the air passes through the bin, it becomes saturated with water vapor and no more drying takes place. There is a distinct drying zone which progresses through the bin. Almost all drying takes place in this drying zone. The grain cannot be considered dry until the drying zone has passed completely through the bin. Grain at the top of the bin will remain at about its initial moisture content until the drying front reaches the top of the bin. Sometimes it will actually gain moisture. As the grain at the top of the bin is the last to dry it is the most susceptible to mold damage. The drying zone must pass through the grain rapidly enough to dry the top layer before mold develops. Corn dried to 15.5 percent moisture will not support significant mold growth. To assure safe storage the corn should be dried to a moisture content of 12 to 14 percent. However, the drying time is not critical in regard to mold damage when the moisture control is less than 15.5 percent.

Allowable Drying Time

The rate of mold growth is also related to the grain temperature. A correlation between the maximum allowable time to dry grain to 15.5 percent moisture and grain temperature has been established and is shown in figure 1.

The grain temperature during drying will be about 10°F. below the average ambient air temperature because of the cooling effect from the evaporation of moisture within the bin. Bin temperatures during the drying process will be from 50° to 60°F., indicating that the maximum allowable drying time would be from 10 to 15 days. See figure 1. This means that if it takes longer than 2 weeks to reduce the moisture content of the corn to 15.5 percent there will be danger of mold growth.

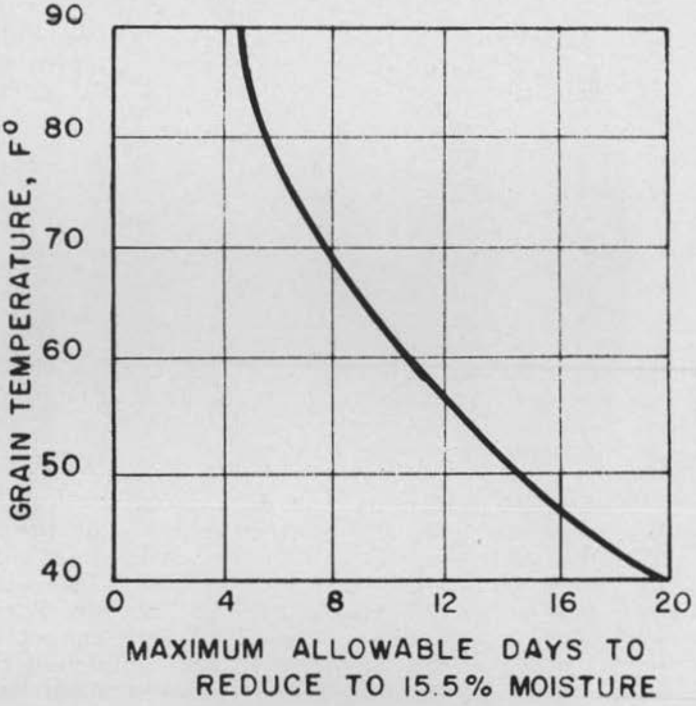

FIGURE 1. A time-temperature limitation curve for drying grain without visible mold damage (2).

factors influencing the drying rate

The drying rate is determined by the air's ability to absorb moisture. The drying air supplies the heat necessary to vaporize the moisture; therefore, the theoretical drying time can be determined from a heat-balance equation:

Heat supplied by the air = Heat required to evaporate the moisture

or $0.24QDT = WJ$

where Q = air-flow rate, lb. per minute per bushel

D = average temperature depression through the bin, degrees F.

T = drying time, minutes

W = pounds of water per bushel to be removed

J = latent heat of vaporization, BTU per lb. of water

0.24 = specific heat of air at constant pressure, BTU per lb.

The variables which affect the drying rate are air-flow rate, temperature depression through the bin, and moisture content of the grain. The temperature depression through the bin is the difference between the temperatures of the air entering the bin and the temperature of the air leaving the bin. The drying process is nearly adiabatic*; therefore, the temperature depression is nearly equal to the wet-bulb depression, which is defined as the difference between the dry-bulb temperature and the wet-bulb temperature of the air entering the bin. If the air leaves the bin saturated, the temperature depression is equal to the wet-bulb depression.

The drying air will leave the bin saturated only if the moisture content of the grain is 24 percent or greater. Below this moisture content the drying air will leave unsaturated, and the temperature depression through the bin will be less than the wet-bulb depression. Air being discharged from corn at 15.5 percent moisture will be about 3°F. above wet-bulb temperature; therefore, all of the wet-bulb depression could not be utilized for drying.

The temperature depression is usually found by subtracting from 0° to 3° F. (depending on moisture content) from the wet-bulb depression. The wet-bulb depression is easily found as it is the difference between wet-bulb and dry-bulb air temperatures. As the moisture content of the grain at the top of the bin will stay at about its initial condition until the drying zone reaches the top, the temperature depression will be nearly equal to the wet-bulb depression until the final drying stages.

presentation of climatological data

Drying with unheated air is always cheapest and will result in the lowest initial investment; therefore, it is preferred when drying conditions permit. Climatological data was gathered to

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* An adiabatic drying process is one in which the drying air supplies all of the heat necessary to evaporate moisture from the product. Moisture being evaporated around a wet-bulb thermometer is also adiabatic; therefore, the temperature of the discharge air will tend to approach the wet-bulb temperature as the drying air becomes saturated.

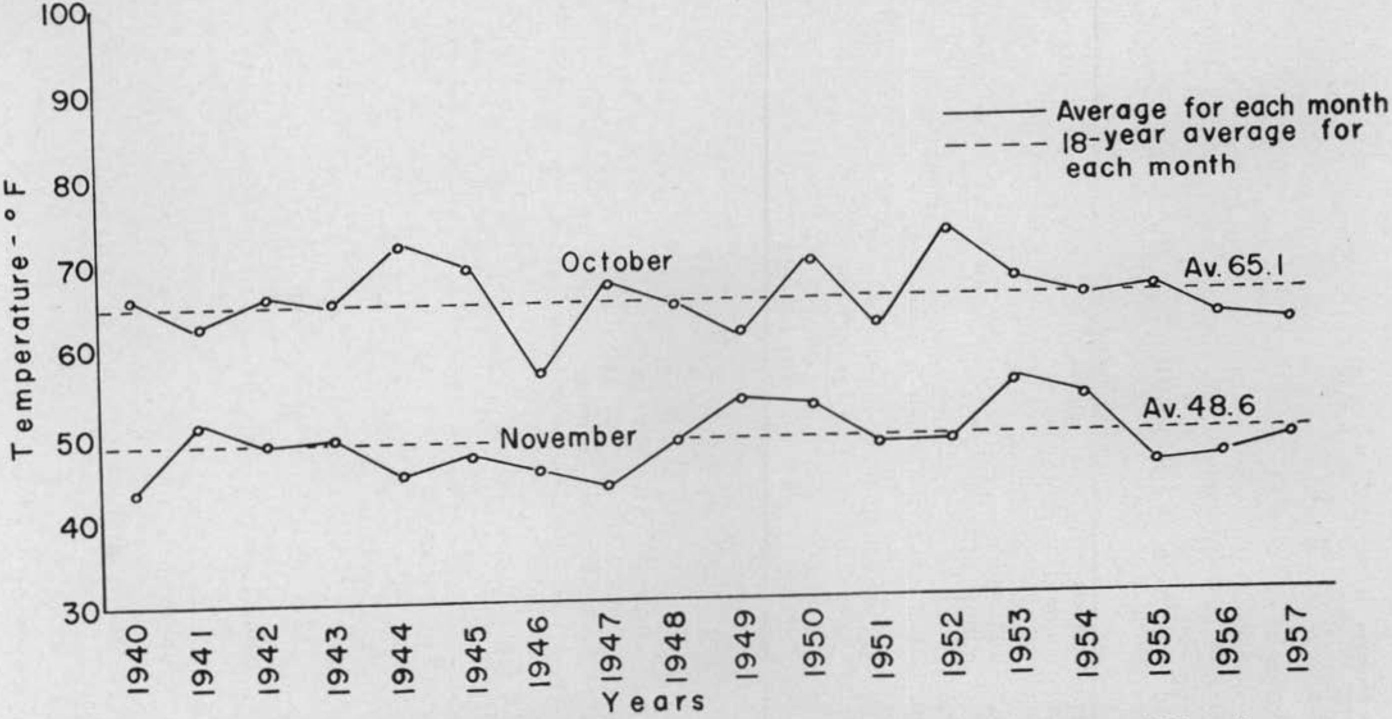

FIGURE 2. Average daily maximum temperatures at Boise, Idaho for the months of October and November.

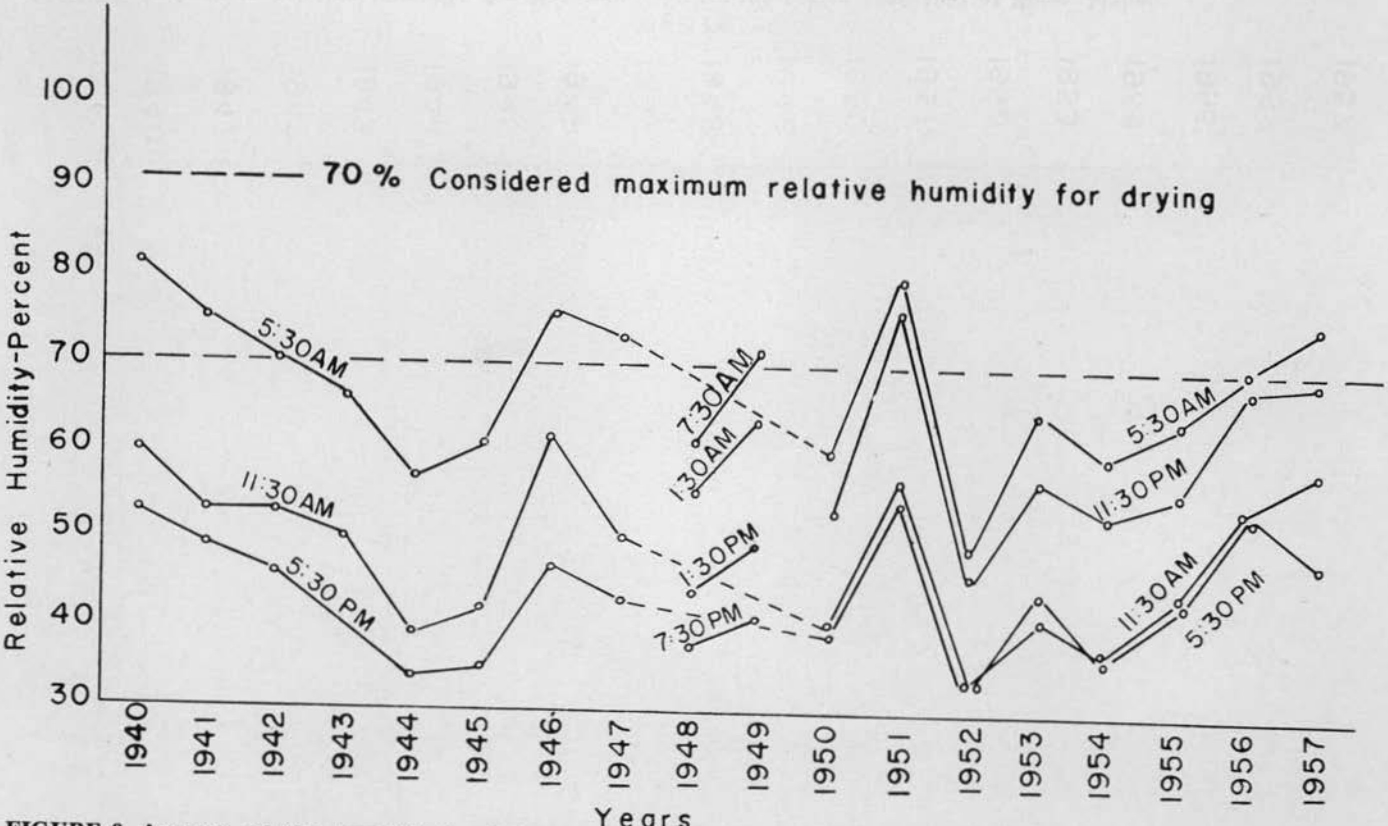

FIGURE 3. Average relative humidity for October during the period 1940-1957 at Boise, Idaho.

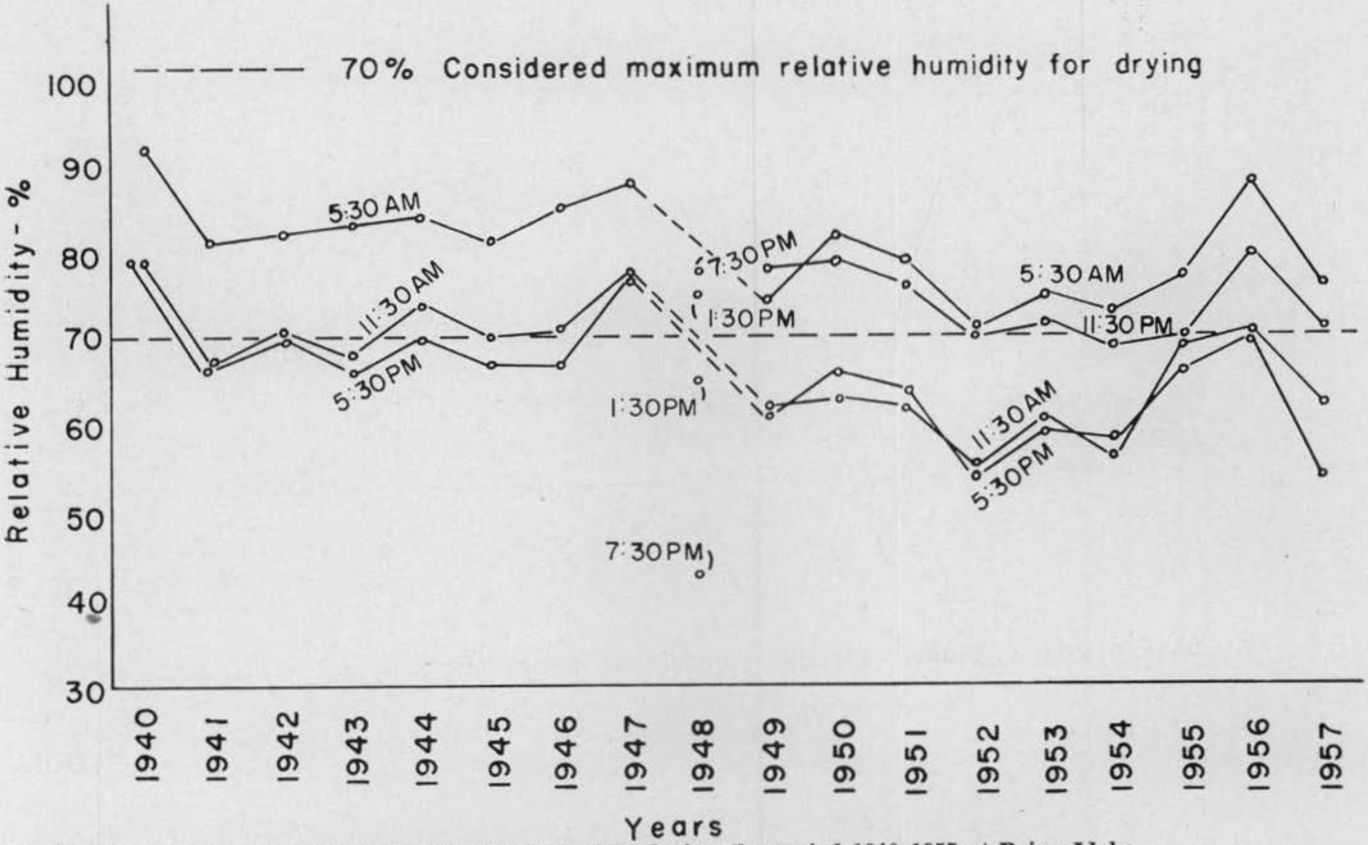

FIGURE 4. Average relative humidity for November during the period 1940-1957 at Boise, Idaho.

determine whether unheated air could be relied upon for drying corn, and if so, what air-flow rate would be required. This data was obtained from the United States Weather Bureau at Boise and is fairly representative of the Boise Valley; however, it will not apply directly to other areas.

For most of the 20 years of weather records, relative humidity was recorded 4 times daily. Presently and for the past few years the relative humidity is recorded hourly. Figure 2 gives average monthly temperatures for October and November for the 18 years of weather records from 1940 to 1957. Figures 3 and 4 give the monthly average relative humidities for the 4 daily readings for October and November.

A relative humidity of 70 percent is considered the highest humidity for removing moisture with unheated air. Figures 2, 3, and 4 show that there are average temperature and relative humidity conditions favorable for drying during October and sometimes in November.

drying tests

All drying was done in 1,000-bushel steel bins equipped with perforated floors. Three-horsepower and 5-hp fans were used for the tests. Several of the fans were equipped with humidistats to stop the fan motors when weather conditions were unfavorable for drying. A 100-square foot solar collector was used to preheat the drying air for one series of tests.

The results of the drying tests are shown in tables 1 and 2. All of the corn was dried satisfactorily with no evidence of mold growth; however, excellent natural drying conditions were present over most of the test period. Operating costs of the drying were unusually low, averaging about 1.5 cents per bushel using unheated air and 2 cents per bushel using LP-gas to heat the air. The low drying cost can be attributed to the excellent natural drying conditions resulting in a minimum amount of moisture which had to be removed.

The lowest operating cost was for the solar drying unit. A study of collector performance and solar climatological data indicates that drying time and operating cost can be reduced 30 percent by using 1 square foot of collector surface for every 3 bushels of corn to be dried. The collector heated the air as it passed above and below a black sheet-metal absorption plate. A glass cover plate was used above the absorption plate. The use of clear 6 mil polyethylene plastic as the cover plate and black 6 mil polyethylene plastic as the absorption plate will result in equal or better collector efficiencies. The clear plastic will deteriorate and will need replacing about once a year.

Table 1. Corn Drying Tests at Caldwell, Idaho

Test No.	Quantity Dried bu.	Percent Moisture at start	Percent decrease in moisture	Type of heat	Air-flow rate cfm per bu.	Hours of fan operation	Ave. wet-bulb depreciation, °F.	Drying cost cents per bu.
1	620	16.0	3.4	Solar	5.7	68	12	0.65
2	1000	15.0	4.0	LP-gas	5.9	96	10	1.48
3	850	20.0	5.0	LP-gas	10.5	147	7	3.6
4	800	18.0	5.0	LP-gas	11.0	196	4	4.8
5	1000	15.0	3.0	LP-gas	5.9	48	5	0.76
6	500	17.0	2.0	LP-gas	18.0	109	3	4.00
7	860	16.5	3.0	Unheated	8.7	86	10	1.08
8	1100	15.8	3.3	Unheated	3.8	222	4	1.35
9	500	20.0	3.0	Unheated	18.0	190	3	2.8
10	590	22.5	9.9	Unheated	14.0	141	5	2.0

Table 2. Drying Costs For Tests at Caldwell. Idaho

Type of Heat	Bushels Dried	Water Removed, pounds	Drying Cost	Cost per bushel cents	Cost per 100 lb. of water removed, cents
Unheated	3950	7800	$ 57.55	1.46	0.74
LP-gas	6100	12,430	122.05	2.00	0.98
Solar heater	620	1326	4.11	0.66	0.31

FIGURE 5. A 3-hp. axial-flow fan used for drying with unheated air.

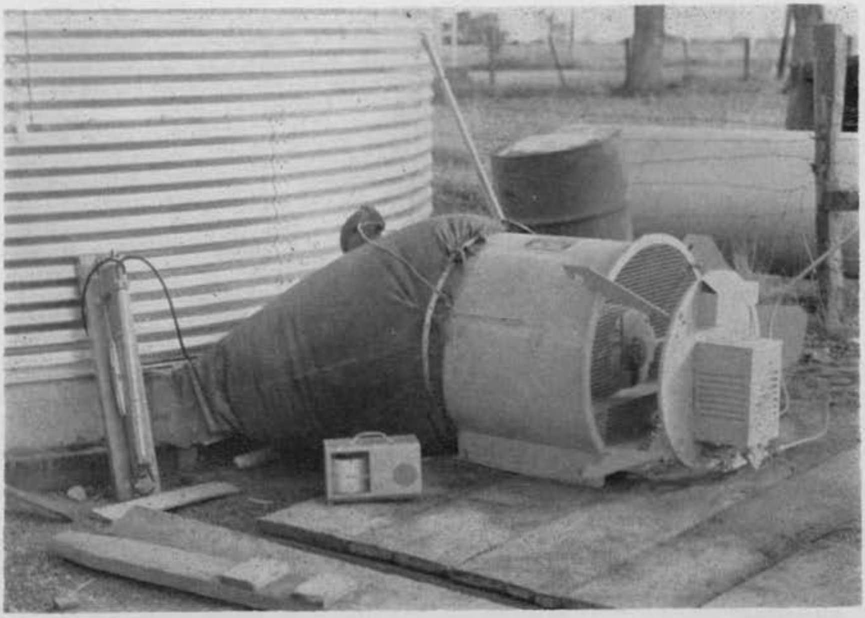

FIGURE 6. A 50,000 BTU per hour LP-gas heater and fan.

analysis of climatological data

The information in figures 2, 3, and 4 indicates that favorable drying conditions are present during parts of October and November. Since the temperatures and relative humidities presented in these figures are average monthly values, they do not indicate the variation in weather conditions during the month.

Adequate drying conditions are necessary to dry the corn in 2 weeks or before mold develops as indicated by the curve in figure 1. Climatological data of temperature and relative humidity was taken from the daily records for the 18 years recorded. From this data the probability of having satisfactory drying conditions for any 2-week period during the drying season was determined statistically. This information has been presented in the form of logarithmic probability curves. Since the wet-bulb depression is an accurate measure of the natural drying conditions, it was used as a drying index.

From the climatological data, the wet-bulb depression was calculated for each hour from 9:30 a.m. to 8:30 p.m. The most favorable drying conditions exist during these hours. These values were used to give the average daily wet-bulb depression. For the period of record when hourly readings were not available the relative humidity at 5:30 p.m. was used to determine the average daily relative humidity.

The average wet-bulb depression for each day was corrected to "temperature depression" by subtracting 1.5 degrees. This means that the discharge air averages 1.5 degrees above the wet-bulb temperature over the drying period. The temperature depression in this form could be used in the heat balance equation to determine drying time. The average daily temperature depressions for the drying day for October and November were tabulated for the 18 years of record. A running sum of average daily temperature depressions for 15-day periods was calculated for each subsequent 5 days for each year as shown in table 3.* (Grain should be dried to 15.5 percent in about 15 days for Idaho conditions.)

The 15-day summation of temperature depressions for each period was plotted on logarithmic probability graph paper. The values plotted as reasonably straight lines, indicating that the data fit a probability distribution. These 15-day summations of temperature depressions are given in table 3. A regression equation was obtained for each of the lines. These regression equations are shown plotted in logarithmic probability paper in figure 7.

From the regression equations, it is possible to determine the probability that the 15-day temperature depression will be a certain value or more. As an example, from the curve it can be seen that the 15-day sum of the average daily temperature depressions for the period of October 31 to November 14 can be expected to be

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* All average daily wet-bulb depressions of 2 degrees F. or less were taken as zero as during these days the relative humidity would be too high for economical drying and the fan would most likely be off.

Table 3. 15-Day Summation of Average Daily Temperature Depression For Subsequent 5-Day Periods For October and November, 1341-1959.

Group No.	1 Oct. 1-15	2 Oct. 6-20	3 Oct. 11-25	4 Oct. 16-30	5 Oct. 21 Nov. 4	6 Oct. 26 Nov. 9	7 Oct. 31 Nov. 14	8 Nov. 5-19	9 Nov. 10-24	10 Nov. 15-29
Year										
'41	184	179	136	77	46	47	59	62	57	67
'42	193	149	104	124	116	99	99	88	96	66
'43	281	209	198	151	137	136	138	120	89	79
'44	328	293	271	184	237	192	112	95	47	70
'45	335	286	258	236	206	153	93	67	81	94
'46	200	217	207	165	137	131	102	94	93	80
'48	251	316	276	259	192	134	132	119	107	85
'49	161	141	162	149	160	119	114	77	25	56
'50	208	214	199	178	150	105	73	55	54	61
'51	128	134	95	103	95	149	82	76	40	39
'52	270	246	219	194	168	140	119	82	46	39
'53	214	184	157	146	136	127	124	129	104	63
'54	211	181	155	162	143	146	133	103	55	37
'55	216	199	174	152	130	89	73	51	38	29
'56	154	124	96	89	40	44	44	63	57	39
'57	134	146	125	107	103	118	110	91	56	61
'58	246	219	213	178	162	145	104	71	71	69
'59	123	120	114	117	101	117	117	114	95	87

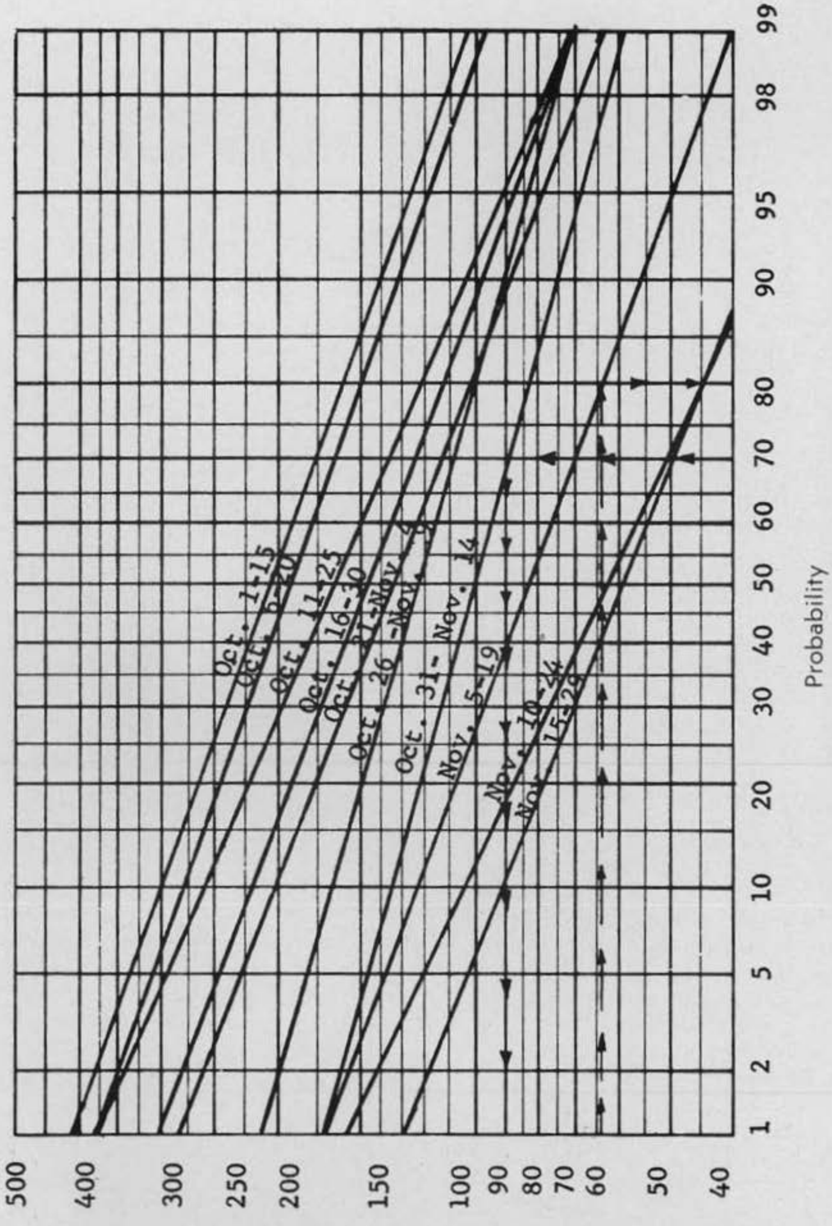

Figure 7. Probability curves for 15-day temperature depressions.

90 or greater 70 percent of the time or 7 years out of 10 years. This could also be read as the 15-day depression will be 90 or less 30 percent of the time or 3 years in 10 years.

minimum drying requirements using unheated air

From the basic heat-balance equation, it is possible to calculate the required 15-day temperature depression to dry a given moisture corn with a given air-flow rate. Figure 8 represents several solutions to the drying equation. With a 70-degree 15-day temperature depression, it would be possible to dry 18-percent-moisture corn with an air-flow rate of 2.4 cfm per bushel, 20-percent-moisture corn with 4 cfm per bushel, 22-percent-moisture corn with 6 cfm per bushel or 24-percent-moisture corn with 8 cfm per bushel. Drying corn of more than 24 percent moisture would not be economical with this 15-day temperature depression using unheated air. Excessive air-flow rates would be required.

Corn is not easily shelled at a moisture content of over 25 percent. Therefore, a moisture content of 25 percent can be considered as a maximum value for harvesting and drying. A well designed system should therefore be capable of drying 25-percent-moisture corn in 15 days using a maximum air-flow rate of 10 cfm per bushel.

From examination of the curves in figure 7 and figure 8, it is possible to show that unheated air cannot be relied upon for drying corn in November. Figure 8 shows that a 15-day temperature depression of 64 degrees is required to dry 25-percent-moisture corn in 15 days with an air-flow rate of 10 cfm per bushel. From figure 7 a 64-degree temperature depression can be expected to occur about 80 percent of the time, if the corn is harvested shortly after November 1. If 10 cfm per bushel air-flow rate is available then drying with unheated air could probably be obtained more than 80 percent of the time as the moisture content will not always be as high as 25 percent when the drying conditions are the poorest. If the corn cannot be harvested soon after November 1 —often the case—then unheated air cannot be relied upon for drying, and heated air should be considered.

heated-air drying

The use of a heater to raise the air temperature 10° to 15°F. will provide drying conditions in almost any weather, thus eliminating the risk present when drying with unheated air. Heaters are usually of the direct type where the products of combustion pass through the grain. Drying costs will nearly always be higher when the air is heated, but drying can be done in any weather and in a shorter time. The most popular fuel for these heaters is LP-gas. The heater capacity in BTU per hour output, to provide a given temperature rise for a given fan output in cubic feet per minute, is given by the approximate relationship:

Heater capacity = (Desired temperature rise) × (Fan output in cfm)

The minimum air-flow rate for drying using heated air can be found from figures 7 and 8 by adding the increase in depression from heating the air. The 15-day temperature depression used in figure 8 must include the increase in temperature depression obtained from heating the air. The increase in temperature depression obtained from heating the air a given number of degrees will not be constant. It will depend on the atmospheric air temperature. Heat added to air at a high temperature will have much more drying ability than the same amount of heat added at a low temperature. The same quality of heat added to air initially at 90°F. will remove about 3 times as much moisture than if added to air initially at 30°F. For average drying conditions add ½°F. to the average daily wet-bulb depression for each 1°F. temperature rise due to the heater.

For example, if a 150°, 15-day temperature depression was read from figure 7, then the daily average depression would be 10°. If the heater provides 12° temperature rise, then the new daily depression would be 10 plus (0.5) × (12) or 16 degrees. The average depression for the 15-day period using heated air would then be (16) × (15) or 240 degrees. From the curves in figure 8 it can be determined that 25-percent-moisture corn could be dried under these conditions with an air-flow rate of 3 cfm per bushel. Under these same atmospheric conditions it would require an air-flow rate of 4.5 cfm per bushel to dry the 25-percent-moisture corn with unheated air. Of course, under more severe conditions it would be impossible to dry the corn with unheated air.

A more accurate mthod of calculating the increase in temperature depression due to heating the air is with the use of the psychrometric chart. This method will give the actual increase in wet-bulb depression due to heating the air a given number of degrees at any given temperature and relative humidity.

Another approximate method of determining the increase in temperature depression due to heating the air is by multiplying the temperature rise by 1/100 of the atmospheric temperature. For example, with an atmospheric temperature of 60°F. and a 10°F. rise through the heater, the temperature depression would be 1/100 × 60 × 10 or 6° F. This value of 6°F. would then be added to the average daily temperature depression. For an air temperature of 50° this would result in adding ½° for each degree temperature rise of the heater.

The average temperature for the drying day in the Boise Valley varies from about 65°F. on October 1 to about 50°F. on November 1 and about 40°F. on December 1.

estimating drying time

The curves in figures 7 and 8 give information for determining the required air-flow rate for drying any moisture-content corn for any time of year. The curves are for a 15-day drying period based on an 11-hour day.

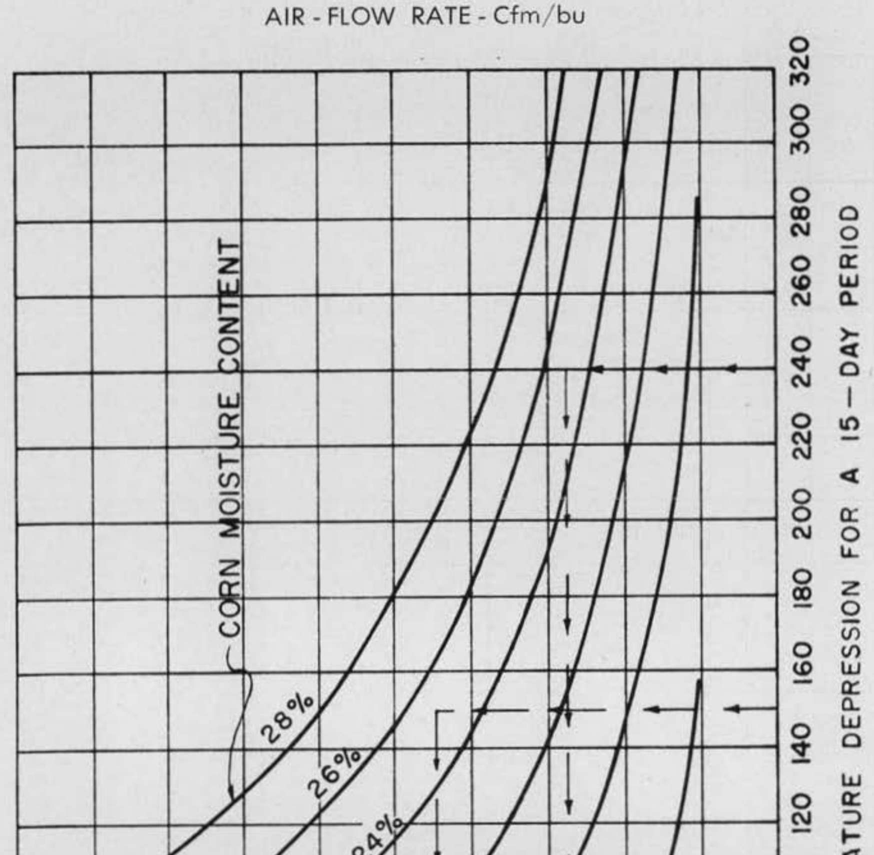

Figure 8. Air-flow requirements for drying high-moisture corn with various temperature depressions.

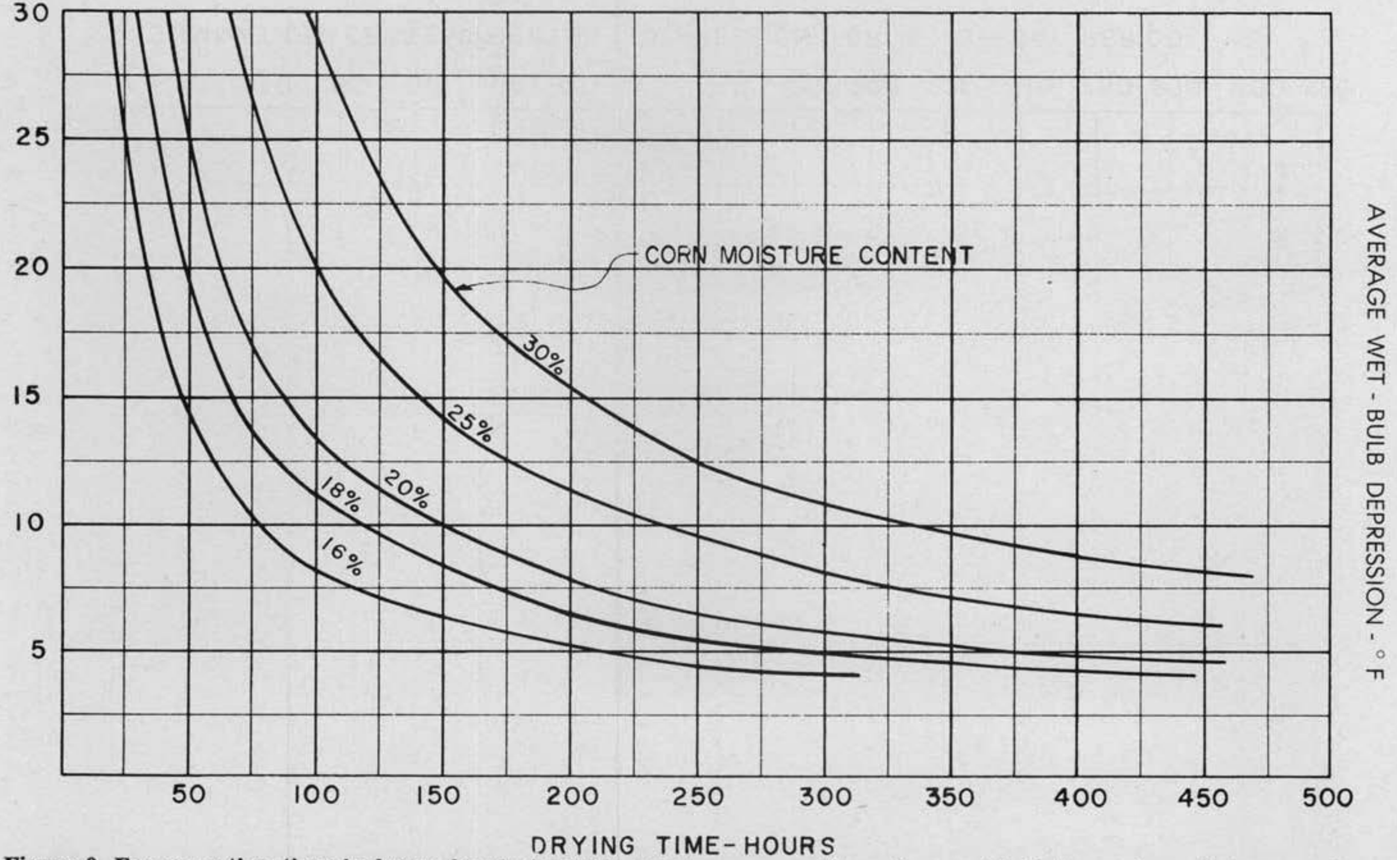

Figure 9. Fan operating time in hours for drying high moisture corn with various wet-bulb depressions. Values are for an air-flow rate of 5 cfm per bushel.

Ability to estimate total drying time for any wet-bulb depression and air-flow rate is desirable. Figure 9 expresses the drying time required for various moisture contents and various wet-bulb depressions for an air-flow rate of 5 cfm per bushel. For other air deliveries the total drying time can be expected to be proportional to the air-flow rate in cfm per bushel. Figure 9 gives the hours of fan operation required to dry the corn to 14 percent moisture.

For any known weather condition, the wet-bulb depression can be read directly from a sling-psychrometer or determined from the psychrometric chart. For heated air the sling psychrometer must be inserted directly into the discharge air duct.

For future conditions the wet-bulb depression can be determined from the 15-day temperature depression in figure 7 from the relationship:

$$\text{Wet-bulb Depression} = 24/11 \; \frac{(\text{15-day temperature depression}) + 1.5}{15}$$

Using this wet-bulb depression, and figure 9 it is possible to estimate the drying time in hours for any air-flow rate, wet-bulb depression, and grain moisture content. Since this method assumes 11 hours of fan operation each day the drying time in days can be found by dividing the time in hours by 11.

The required drying time using heated air can be found in the same manner as was done using unheated air except the increase in wet-bulb depression due to heating the air must be added to the natural wet-bulb depression.

estimated operating drying costs

The cost of drying can be divided into fixed and operating costs. The operating cost is power and fuel expense directly proportional to the drying time. Figure 10 relates the operating cost to the drying time for various sizes of fans and heaters. The cost of operating the dryer will usually be from 1 cent to 3 cents per bushel when using unheated air and 2 cents to 5 cents per bushel for a heated air system.

The fixed cost for drying with unheated air will include the cost of the fan, bin, controls, wiring, discharge duct, and perforated floor or other air-distributing system. The cost of the bin may not always be justified as a drying expense. Many growers have bins which they use for grain storage. Often these bins would also be available for drying. The total fixed cost and the yearly fixed cost for the drying equipment used in the drying tests for unheated air is summarized as follows:

Fixed Cost

1000-bushel steel bin	$ 460.00
Perforated floor	290.00
3 hp electric motor, fan, controls and discharge duct	448.00
Wiring	10.00
TOTAL INVESTMENT	$1208.00

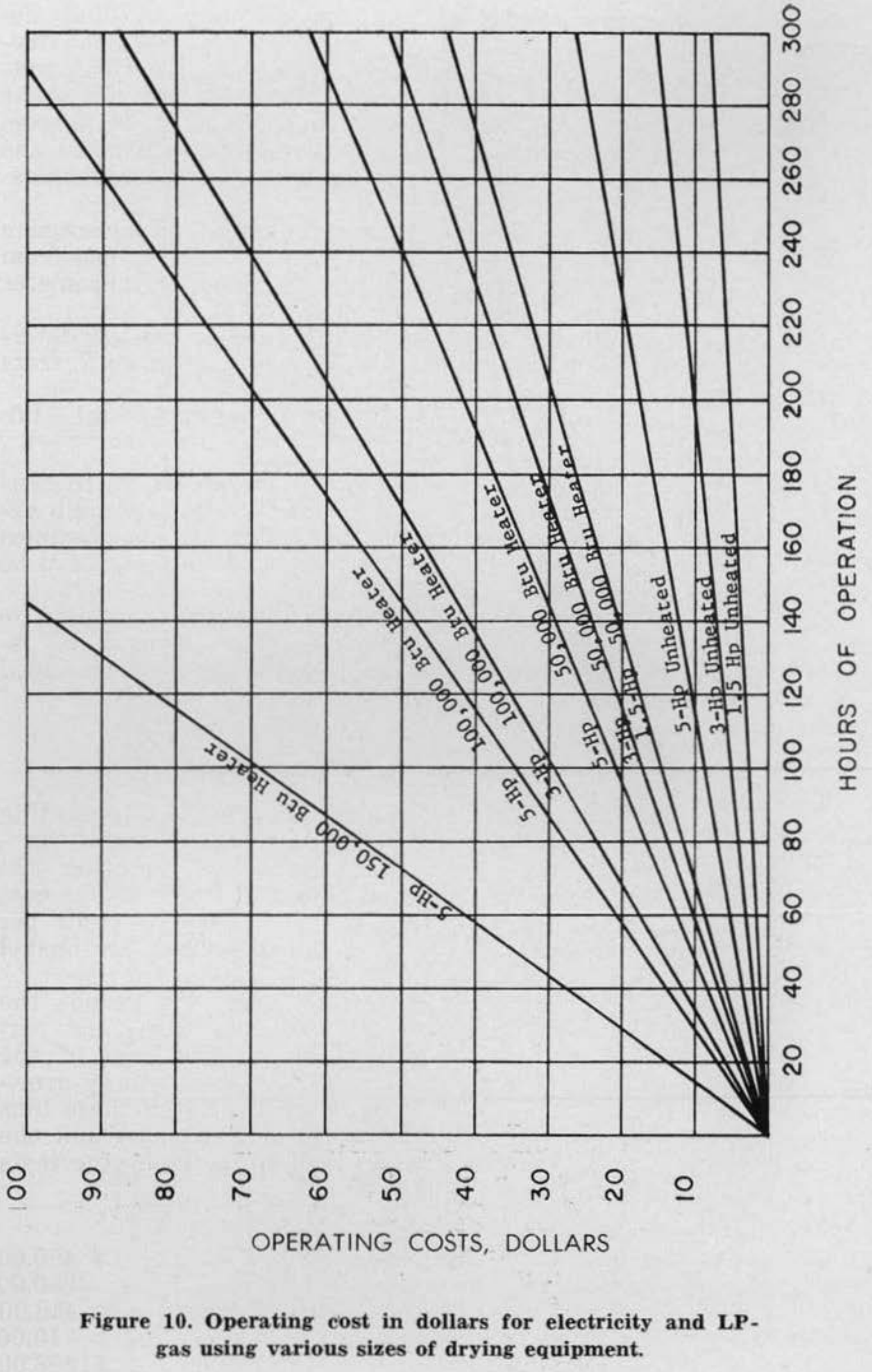

Figure 10. Operating cost in dollars for electricity and LP-gas using various sizes of drying equipment.

Yearly Fixed Costs

Depreciation of bin and floor (15-yr. service life)	$ 50.00
Depreciation of fan and controls (10-yr. service life)	46.00
Interest on investment (6 percent on ½ the investment)	36.00
Repairs	6.00
Fixed Cost Per Year	$138.00

If an LP-gas heater is used, the cost of the heater and storage tank must be added. The additional fixed cost for the LP-gas unit is:

Additional Fixed Cost

LP-gas heater (50,000 BTU per hour)	$100.00
Copper tubing, fittings, and regulator	14.00
Storage tank (115 gallons)	168.00
Additional Investment	$282.00

Additional Yearly Fixed Cost

Depreciation on heater (10-yr. service life)	$ 11.40
Depreciation on tank (15-yr. service life)	11.20
Interest on investment (6 percent)	8.45
Cost Per Year For The Heater Unit Only	$ 31.05
Fixed Cost Per Year For The LP-Gas Dryer	$169.05

total cost of drying

The total cost for drying corn from 25 percent moisture to 14 percent moisture with unheated air and LP-gas-heated air was compared for average early November Idaho conditions. The comparison was made using a 3-hp fan for both installations and a 50,000 BTU heater for the heated-air system. The cost per bushel is given for drying one, two, and three 1000-bushel batches per season with each unit. The calculations were based on the cost of electricity at 1.75 cents per kilowatt-hour and LP-gas at 20 cents per gallon. This information is given in table 4. From this comparison it can be seen that the total drying cost per bushel decreases as the number of batches increases. Although the drying cost using LP-gas is higher, the total cost per bushel may be cheaper due to the shorter drying time, and the possibility of drying more than one batch. If only 1 batch is dried with unheated air the cost is 15.4 cents per bushel, but if the use of heated air will allow 2 batches to be dried the cost per bushel is 16.3 cents per bushel.

Tables 2 and 4 show that power and fuel drying costs are small—from 2 cents per bushel for unheated air to 3 cents per bushel for heated air—as compared with the original equipment cost. The original cost can be reduced by converting existing storage to drying units. This conversion can be done by installing an air-distribution system into the existing storage bin and sealing all cracks. An air exhaust outlet must also be provided. A 3-hp fan will dry up to 1200 bushels and a 5-hp unit will be adequate for drying 2000 bushels at one time. A 5-hp fan used for grain drying can also be used for drying hay earlier in the summer thus adding justification for the high initial cost.

Table 4. Comparison of Total Drying Costs Using Unheated Air and Heated Air

	Unheated Air		
	1 bin per yr.	2 bins per yr.	3 bins per yr.
Power cost	$ 15.85	$ 31.70	$ 47.55
Fixed cost	$138.00	$138.00	$138.00
Total cost	$153.85	$169.70	$185.55
Cost per bu.	15.4 cents	8.5 cents	6.2 cents
	Supplemental LP-Gas Heated Air		
Power cost	**$ 8.80**	**$ 17.60**	**$ 26.40**
Fuel cost	**$ 19.20**	**$ 38.40**	**$ 57.60**
Fixed cost	**$169.05**	**$169.05**	**$169.05**
Total cost	**$197.05**	**$225.05**	**$253.05**
Cost per bu.	19.7 cents	11.3 cents	8.4 cents

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