SIMULATION OF GRAIN SORGHUM DRYING BY NATURAL AIR

by

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Santa Cruz, Bolivia, 1976

A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

FOOD SCIENCE

Department of Agricultural Engineering

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1981

Approved by:

Major Professor

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1. INTRODUCTION

Among the major grain sorghum producing states, Kansas is actually a leading sorghum state in this nation (Jackson et al., 1980).

Because of the large grain sorghum production, off farm commercial storage and on farm storage capacities have been increased considerably. Consequently, many investigators are working in the problems of grain sorghum storage to determine optimum or recommendable storing and handling conditions.

As is known, grain sorghum must be dried to a certain level of moisture content before storing for a given period, but the constant increase in the petroleum fuel costs and increased competition for petroleum products have made the conservation of energy an important cost and management factor. In this sense, many systems were studied and the results led to the conclusion that natural air drying of grains offers potential for reducing energy requirements and it is often most effective when used in combination drying (Morey et al., 1979) where the high temperature dryer reduces the moisture content to a level where drying can be completed in storage with ambient air. According to Foster (1953), mechanical ventilation with unheated air offers certain advantages over heated air because it is less expensive, requires less supervision and generally presents less fire hazard than drying with heated air. However, the effectiveness of unheated air drying is dependent on the uncontrollable weather conditions and other factors like moisture ranges through which grain is to be dried, airflow rate, initial grain moisture content, grain depth and harvest dates. Thus, it becomes important to evaluate these factors and to establish the recommended conditions to dry the grain without objectionable quality deterioration. This would require the operation of a large number of field or laboratory facilities for several years so that this approach becomes prohibitive in funds and time required. Therefore, simulation by means of computer programs became the substituting way to predict the feasibility of grain sorghum drying by natural air. In this sense and considering that there were no specific information of grain sorghum drying systems for this area of Kansas; this study was made in order to establish recommended natural air drying systems for grain sorghum under the Kansas weather.

2. OBJECTIVES

The general objective of this work was to evaluate the grain sorghum drying performance by means of a simulation computer program, and to predict the feasibility of practicing the grain sorghum drying by natural air in various districts in the State of Kansas.

Specific objectives were:

1. To show the effects of changes in yearly weather conditions on the natural-air drying performance.
2. To examine the effect of airflow rates on dry matter loss and grain moisture content along the grain bed depth for various initial grain moisture contents.
3. To determine the drying time necessary to reach a grain moisture content for a safe storage.
4. To determine a recommendable airflow rate for a given grain depth and initial moisture content of grain.

3. LITERATURE REVIEW

3.1 Kansas Grain Sorghum Production

3.1.1 Production by Districts

In order to determine the study areas for the simulation of drying operation in Kansas, it was necessary to know the major districts for grain sorghum production. Table 1 summarizes grain sorghum production by districts in Kansas for the last four years. Figure 1 shows a breakdown for boundary of districts in Kansas.

Table 1. Grain sorghum production by districts in Kansas.[10.]

	Production (Bushels)			
Districts	1976	1977	1978	1979
Northwest	3,923,600	8,643,500	5,796,700	7,373,000
West Central	5,912,100	9,185,900	7,755,600	10,622,100
Southwest	32,091,200	38,232,300	43,323,900	45,121,300
North Central	20,512,500	35,762,400	28,877,700	37,172,000
Central	16,905,300	27,282,500	21,599,800	26,635,900
South Central	17,289,700	29,662,600	21,577,600	24,628,400
Northeast	29,332,800	33,754,200	36,889,100	40,467,800
East Central	21,220,400	31,716,600	24,418,800	36,118,300
Southeast	22,662,400	28,760,000	18,800,800	28,541,200

10. Kansas Crop and Livestock Reporting Service. 1980.

3.1.2 Harvest Dates in the Kansas Districts

In general, usual harvesting dates in the state of Kansas are:

Begin: September 20

Most active: October 10-November 10

End: December 1

THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.

THIS IS AS RECEIVED FROM CUSTOMER.

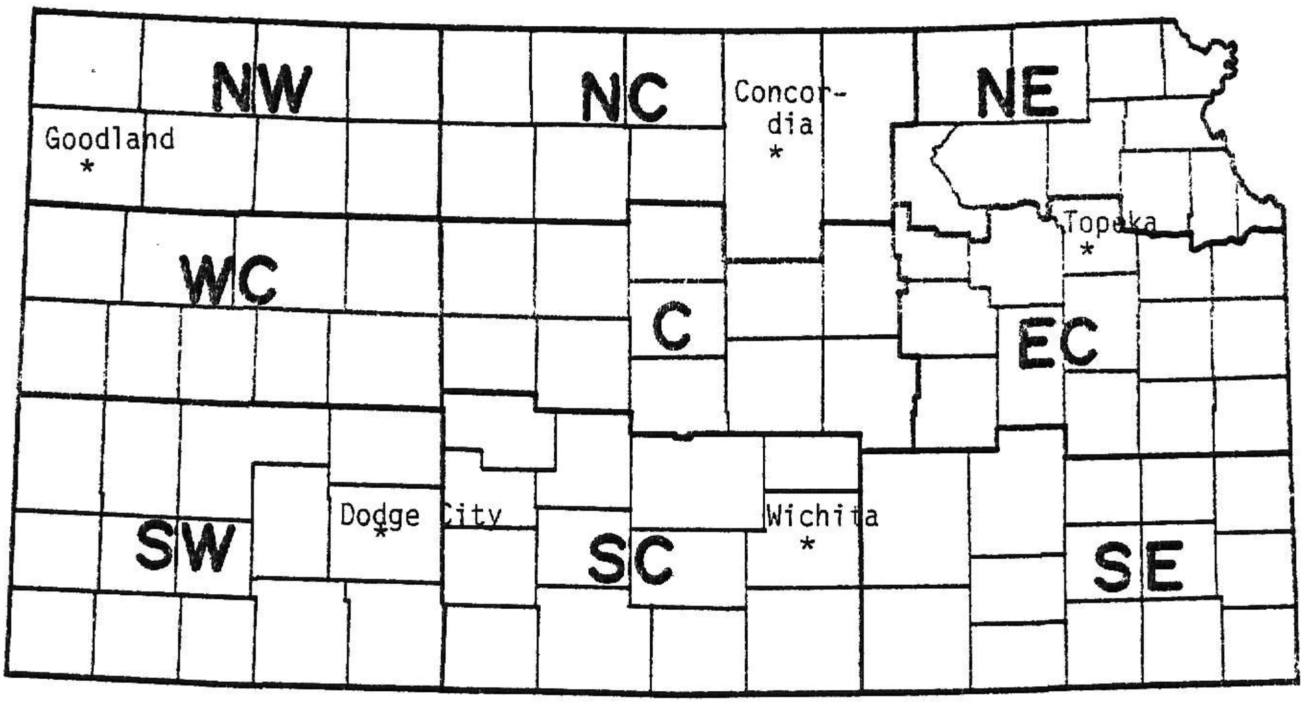

Figure 1. Kansas Districts. The districts are designated as follows: northwest (NW), west central (WC), southwest (SW), north central (NC), central (C), south central (SC), northeast (NE), east central (EC), and southeast (SE).

In Tables 2 and 3, percentages harvested by specified dates are shown for two periods.

Table 2. Percentage of sorghum acreage harvested, Kansas, 1963-1973 average.[11]

	October				November		
District	1	10	20	30	10	20	30
Northwest	0	10	30	50	70	85	90
West Central	5	10	25	45	70	80	90
Southwest	5	10	25	45	65	80	90
North Central	10	15	35	55	75	85	90
Central	15	20	40	55	70	85	90
South Central	15	20	35	50	70	80	85
Northeast	20	35	50	70	80	90	95
East Central	25	45	60	70	80	90	95
Southeast	50	65	75	85	90	95	100
State	15	25	40	55	75	85	90

[11] Kansas Crop and Livestock Reporting Service. August 1979.

Table 3. Percentage of sorghum acreage harvested, Kansas, 1973-1977 average.[11]

	October				November		
District	1	10	20	30	10	20	30
Northwest	0	10	35	65	85	90	95
West Central	5	15	35	55	70	85	95
Southwest	5	15	30	50	70	80	95
North Central	10	20	40	60	80	90	95
Central	10	20	35	55	70	85	95
South Central	5	15	30	50	65	75	90
Northeast	25	35	50	70	80	90	95
East Central	25	40	55	65	80	85	95
Southeast	40	50	55	70	80	85	95
State	10	25	40	60	75	85	95

3.2 Kansas Weather

3.2.1 General Narrative Climatological Summary of Kansas Weather[11]

Kansas climate is a distinctly continental type with invigorating large daily, seasonal and annual temperature changes. The precipitation pattern also is subject to seasonal variations, with annual differences from west to east across the State much larger than variations from north to south. In addition to these short-time changes there are occasional periods of drouth in which several years with low rainfall and high temperatures follow each other, and periods of flood in which heavy rainfall recurs. Between these irregular extreme periods are individual

[11] Kansas Crop and Livestock Reporting Service. August 1979.

years or periods of years in which more nearly normal temperatures and precipitation prevail. No two years are alike.

Most of Kansas is subject to extreme temperatures of 110° to 120°F on the warm side and as cold as -25° and -30°F. However, such extremes are the exception. Normally, days per year on which the temperature rises to 90°F or above ranges from 50 in the northeast to 80 in the south central. The number of days 100°F or higher averages 10 in the northeast and increases to about twice that number over much of the central third. The number of days per winter in which the maximum temperature does not rise above 30°F is about 15 for the Oklahoma border counties to almost double that near the Nebraska line. The number of mornings per year with a minimum of 32°F or lower is approximately 100 in the southeast and rises to 160 in the northwest. Number of days with zero or lower temperature averages 10 annually in the extreme northwest but only 2 in the south central counties.

The average freeze-free period extends over approximately 200 days in the southeast but is reduced to 150 days in the northwest.

3.2.2 Narrative Climatological Summary by Regions[21].

Topeka.

Topeka, located near the geographical center of the United States, close to the western edge of the prairie-lands corn belt, the southern edge of the glacial drift, and about the middle of the temperate zone, offers all the variety in weather generally found in an inland locality separated by mountains or great distances from the modifying influence of the ocean.

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21. U.S. Department of Commerce. Weather Data Library, Manhattan, Kansas.

Normally more than 70 percent of the annual precipitation falls during the six crop-growing months, April through September. The rains of this period are usually of short duration, predominantly of the thundershower type and occur more frequently during the nighttime and early morning hours than at other times of the day.

The greatest 24-hour amount of record is 8.08 inches on September 6-7, 1909. Twenty-four-hour falls of 5 inches or more occur about once in 9 years; 4 inches or more four times in 10 years; 3 inches or more eight times in 10 years; and 2 inches or more five times every 2 years. Rainfall, amounting to an inch in an hour, occurs with a frequency of five times every 2 years, and falls of 2 inches in two hours can be expected one year out of two. Maximum falls observed in various time periods are: 5 minutes, 0.90"; 10 minutes, 1.40"; 15 minutes, 1.55"; 20 minutes, 2.08"; 30 minutes, 2.92"; 60 minutes, 4.16"; and 120 minutes, 4.77".

Dry summers are hot with low relative humidity and persistent southerly winds; years with more moisture are cooler. Oppressively warm periods with high relative humidity are usually of short duration.

Winters average about 50°F cooler than summers. Cold spells are seldom prolonged; only on rare occasions do daytime temperatures fail to rise above the zero mark. Cold air invasions are usually ushered in by strong north or northwesterly winds, but less than half of these are accompanied by precipitation. Winter precipitation is often in the form of snow, sleet, or glaze, but storms of such severity as to prevent normal movement of traffic or to interfere with scheduled activity are not common. Blizzards are infrequent.

Autumn is characteristically a season of warm dry, cool nights, and infrequent precipitation, with cold air invasions gradually increasing in intensity as the season progresses.

Nearly all crops of the temperate zone can be produced in the vicinity of Topeka with its growing season of almost 200 days.

Dodge City.

The climate of Dodge City and southwestern Kansas is classified as semiarid. Dodge City is nearly 300 miles east of the Rocky Mountains, but the weather reflects the influence of the mountains. The mountains form a barricade against all except high level moisture from the southwest, west, and northwest. Chinook winds occur occasionally but with less frequency and effect than at stations farther to the west. Relatively dry air predominating with an abundance of sunshine contribute to broad diurnal temperature ranges.

The average annual precipitation accumulates to near 20 inches. Thunderstorms during the growing season contribute most of the moisture. In general, the thunderstorms are widely scattered, occurring during the late afternoons and evenings. Winter is the dry season.

The extreme temperatures recorded for Dodge City range from 109° to -26°F. Afternoon temperatures in the nineties prevail during the summer months; temperatures above 100°F are the exception. Due to low humidity and a continual breeze, these temperatures are effectively moderated. Temperatures drop sharply after sunset. Temperatures below zero are infrequent and of only a few hours duration each winter.

Western Kansas is noted for clear skies and abundance of sunshine with seldom a day the sun fails to shine.

Wichita.

Wichita lies in the path of alternate masses of warm, moist air moving northward from the Gulf of Mexico and cold, dry air moving southward from the Polar Regions. Consequently, weather in this area is subject to frequent and often abrupt changes. Summer months are usually warm and occasionally the term "hot" is a better description. On the average, temperatures of 90°F or above occur on 60 to 65 days per year, while readings of zero or lower occur on about two days per year.

Wichita has an elevation of a little more than 1,300 feet above sea level. The average freeze-free period has a duration of about six and one-half months, extending from mid-April to late October.

It is of significance to agriculture that a large portion of the precipitation falls during the growing season. The six months, April through September, account for about 70 percent of the annual precipitation.

The heaviest amounts of snow occur in the months of December through March.

The prevailing wind direction is southerly and the average velocity compares with other midwestern areas. Strong northerly winds often follow the passage of the occasionally severe cold fronts characteristic of Great Plains weather.

Concordia.

A wide variety of weather occurs in this vicinity which makes possible a great range in crop production.

Precipitation is light during the winter months, increasing in the spring until June and dropping off during the autumn months. Thunderstorms are frequent in May, June, July, and August. Although heavy falls of snow are not uncommon, severe storms that paralyze industry and agriculture are very rare.

The average annual range in temperature is from 5°F below zero to 104°F. Sustained periods of hot, dry, and windy weather frequently occur in July and August with temperatures of 100°F or more recorded for a week at a time. The average date in the autumn for the first 32°F temperature is October 21.

A period of mild, dry Indian Summer weather usually occurs in October and early November before the winter snow and cold begin.

Goodland.

Goodland is situated on an intermediate plain with very few native trees. The terrain rises gradually from east to west with only minor variations from north to south. The rate of rise is about 1600 feet per 150 miles to the east of Goodland and about 2500 feet per 150 miles to the west. This gradual slope in terrain makes conditions favorable for upslope fog, low clouds and drizzle with easterly winds, particularly during the spring months.

This is a typical steppe climate with wide variations in precipitation from year to year. Evaporation generally exceeds precipitation during the summer months. The mean monthly rainfall increases in the spring to a maximum in June. The frequency of thunderstorms normally increases to a maximum in July with a marked decrease in September.

The heaviest snowfall is most likely to occur in March, although heavy snows have been recorded in every month from October through May.

Temperatures follow the usual continental regime with January normally the coldest month and July the warmest. Subzero temperatures occur frequently in January and February and have occurred as early as November 2 and as late as March 27.

Considering the importance of the yearly changes of weather in Kansas it was necessary to analyze quantitatively the temperatures and relative humidities in the study areas. For this purpose, Figure 2 shows the average temperatures and relative humidities during October and November from 1963 to 1973 for the areas of Topeka, Dodge City, Wichita, Concordia and Goodland.

3.3 Grain Sorghum Drying by Natural Air

Slow-drying of high moisture grain sorghum tests conducted by Converse et al. (1973), have established that any delay in controlling humidity and temperature in moist grain will provide favorable conditions for storage fungi to invade. Their conclusions were:

1) Airflow rates of 1½ to 2 c.f.m. per bushel were effective and efficiently controlled mold invasion for 22½ percent moisture sorghum.

2) Success depends upon maintaining continuous fan operation until moisture content of the surface grain is below 14 percent.

Thompson et al. (1969) studied the performce of various temperature control systems for chilled high-moisture grain storage, and concluded that under some conditions a system with continuous aeration will perform better than more complicated systems using mechanical refrigeration.

Performance of low-temperature, solar-heated and ambient air drying systems has also been evaluated by Pierce and Thompson (1976), Bakker et al. (1977) and Morey et al. (1977). These studies showed that grain drying by natural air was effective and efficient method of drying. The results showed that drying could be completed within safe storage limits if airflow rates were matched with initial moisture contents. Results

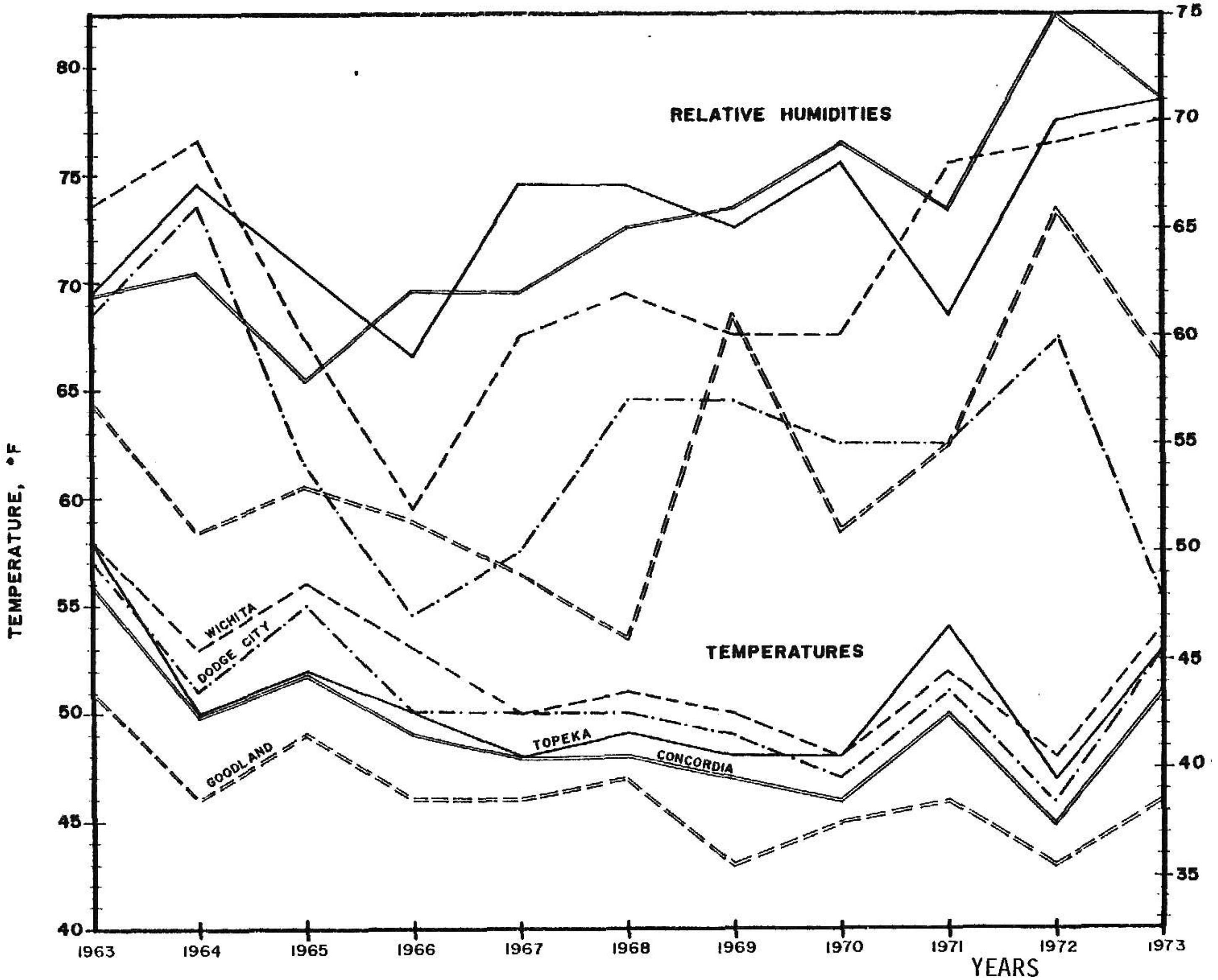

Figure 2. Average temperatures and relative humidities during October and November in five areas of Kansas.

also showed that by increasing airflow rates 10 to 15 percent, ambient air drying was equivalent to solar supplemental heat drying. Experimental and simulated results (Morey, 1977), have also indicated that adding 1 to 2°C temperature rise to the drying air with electric or fossil fuel sources significantly increases the energy requirement per unit of water removed compared to ambient air drying.

Another important experiment on ambient and solar-heated air drying for sorghum and corn was conducted by Converse, Foster and Sauer (1977). They concluded that drying rate was mainly dependent on airflow rate and grain deterioration was confined to the upper grain layers and mainly in areas of reduced airflow rate due to fine-material in the grain. Their results can be seen in Table 4.

Table 4. Description of Converse's grain sorghum drying test by natural air.[1]

Bin Diameter (feet)	Harvest Dates	Grain Depth (feet)	Average Moisture Content		Continuous Fan Operation (days)	Airflow Rate (cfm/bu)
			Initial (%)	Final (%)		
15	Nov. 16	4.1	20.4	16.2	28	3.32
15	Sept. 17	5.5	23.6	14.2	22	2.15

[1]Tests developed at U.S. Grain Marketing Research Center, Manhattan, KS.

The U.S. Department of Agriculture recommended the conditions for natural air drying of grain sorghum shown in Table 5 (Sorensen and Crane, 1960).

Table 5. USDA recommended conditions for natural air drying of grain sorghum.

Grain Moisture Content, %	Recommended Maximum Depth of Grain, feet	Recommended Minimum Airflow, cfm/bu
20	8	3
18	10.5	2
16	16	1

Note: These values are somewhat conservative. No location specified.

Recently ambient air drying systems for shelled corn were conducted by Morey et al. (1979). Their drying performances were simulated by using various years of weather data in St. Cloud, MN, Des Moines, IA and Indianapolis, IN. Their more important conclusions were: 1) continuous fan operation, under an appropriate fall shut-off and spring start-up procedure, is preferable to management strategies which involve turning off the fan based on relative humidity, temperature, or a time clock; 2) filling the bin over a period of time allows an increase in allowable initial moisture content of up to 3 percentage points, depending on the schedule, compared to a single-fill procedure; 3) increasing airflow to 2.2 m^3/min-t (2 c.f.m./Bu) for a full bin (10.7 feet-depth) allows the initial moisture content to be increased to as much as 27 percent on a delayed-fill schedule, but fan power and depth restrictions may limit this application; and 4) stirring offers potential advantages for reducing maximum dry-matter decomposition and minimizes overdrying. Stirring at 7- to 14-day intervals appears to be preferable to continuous stirring.

Solar Energy subcommittee of the Midwest Plan Service, 1980, also published some results for corn drying by natural air using a bin 30 feet in diameter with 17.5 feet of shelled corn. Table 6 shows the details.

Table 6. Low Temperature and Solar Grain Drying Handbook results (based on 28 years of average weather data for Des Moines, Iowa) for corn drying.

	Bin #1 10 Hp 1.1 cfm/bu 3.13" SP 2.5°F from fan	Bin #2 10 Hp 1.1 cfm/bu 3.13" SP 2.5°F from fan 2.5°F supplem. heat	Bin #3 20 Hp 1.4 cfm/bu 4.63" SP 3.8°F from fan
Date start	Oct. 15	Oct. 15	Oct. 15
Initial corn M.C., % w.b.	22	22	22
Date dry	Nov. 30	Nov. 22	Nov. 13
M.C. range, %	13.3 to 15.5	12.1 to 15.2	12.5 to 15.4
Avg. final M.C., % w.b.	14.2	13.2	13.4
Temp. range, °F	34.5 to 34	41 to 39.2	44.8 to 42.7
Fan hours, drying	1,104	912	696
Kilowatt hrs, used	9,685	16,027	12,212

All of the experiments and results mentioned above, indicate that grain sorghum drying by natural air was successful for specified conditions of airflow rate, grain depth and initial moisture content, but actually there are no specific recommendations for applying ambient air drying in the main areas of grain sorghum production in Kansas.

3.4 Index of Grain Deterioration

Grain deterioration is one of the main variables that needs to be controlled with temporary storage procedures. This deterioration is a function of the respiration or oxidation of the grain and is highly dependent on the temperature and moisture content of the grain (Thompson, 1972). Steele et al. (1969) measured carbon dioxide production from shelled corn held under various conditions and related this to dry matter decomposition of the shelled corn. Families of curves were presented to permit calculation of permissible storage times as a function of the temperature, moisture content and mechanical damage of the corn kernels.

Saul's studies (U.S. Department of Agriculture, 1968) indicated that with a 0.5 percent dry matter decomposition, corn loses some quality but keeps its market grade. If the decomposition is higher, loss in quality reduces the market grade. Thus, 0.5 percent decomposition is about the limit without a reduction in grade.

There are other tests that are used to determine the condition of grain and to predict its future storage behavior. Those tests include: 1) visual observation; 2) increased fungal population; 3) decrease in germinability or viability; 4) heating; 5) production of toxins; and 6) various biochemical changes, including those that result in mustiness, souring, high fat acidity, or bitterness.

4. DIGITAL COMPUTER SIMULATION PROGRAM

The original computer program called KSUDRYER was developed by Samuel G. Maurer in cooperation with Dr. Harry B. Pfost (Kansas State University, Food and Feed Grain Institute, 1978) and prepared for the Agency for International Development, U.S. Dept. of State.

The basic model developed for corn, was tested against actual drying results obtained in tests conducted by the U.S.D.A. Grain Marketing Research Center, Manhattan, Kansas, and found to be acceptable.

KSUDRYER was extended to grain sorghum by Dong I. Chang under the supervision of Dr. Do S. Chung (KSU, Agricultural Engineering Department, 1979). This modified program was also validated and deposited on tape under the name SORGMDRY, which was used in the drying simulations.

The following four sections were extracted from the report prepared by Samuel G. Maurer and Dr. Harry B. Pfost, 1978 (KSU, Food and Feed Grain Institute, Research Report No. 13, September, 1978).

4.1 General Description

KSUDRYER (SORGMDRY) is a program written to predict drying performance of natural or supplemental heated aeration grain dryers. The program reads in the design parameters of grain type and condition, loading data, fan curve(s) and fan management control variables. The program then computes the final conditions of grain and air for each layer within the bin at each time interval. Output can consist of: input parameters, input weather data, interpolated weather data for further study, intermediate grain conditions, final grain conditions, energy requirements and drying time required.

4.2 Input Requirements

A. JCL

```
//JOBNAME JOB(SSN, ACCT NUMBER),'YOUR NAME', TIME=(,29)
```

Should the user specify values for external files, NVALID, NOUTWR, NTABLE additional JCL may be required in these locations. This example has NREAD=5, NPRINT=6, NWTHR=3.

```
//EXEC FORTGG, P=SORGMDRY
//STEPLIB  DD  DSN=DSKN7.LOADLIB,DISP=SHR
```

Should the user specify values for external files, NVALID, NOUTWR additional JCL may be required in these locations. This example has NREAD=5, NPRINT=6, NWTHR=3, NTABLE=13.

```
//GO.FT03F001  DD  DDNAME=SYSIN1
//SYSIN1  DD *

   Weather Data Deck

/*
```

i.e.:

```
//GO.FT13F001  DD  SYSOUT=A,DCB=(RECFM=UA, BLKSIZE=133)
//GO.SYSIN  DD  *

   Problem Decks

/*
```

B. Weather Data Decks

The program allows multiple sets of weather data to be used during a single job. However, a problem deck and file number (NWTHR) must be supplied for each weather deck. Each weather deck consists of card images of the following format (4(I3,I2,I3 I2,F4.2,2X),2X,A4,A2,8X). The first field of numbers are:

1. NPS - Number of weather data points to be read in this weather deck
2. IDT - Indicating variable for weather data time interval.
   0 - Mixed time interval or missing data
   1,2,3,4 etc. - Time increment of consistent weather data (hours)
3. IDUMMY - Dummy variable, Blank space
4. IYR - Year of weather collection, i.e., 59=1959
5. ELEV - Elevation of weather station above sea level in thousands of feet. Used for calculation of atmospheric pressure if actual data not available. If 0.0, atmospheric data is supplied.

6-10 are repeated for each weather data point:

6. IDAY - Julian Day i.e., (1-365) of weather measurement
7. IHR - Hour of the day (0-23) of weather measurement
8. IDB - Dry bulb temperature (°F)
9. IRH - Relative humidity (percent)
10. PATM - Atmospheric pressure if available (inches of Hg)
11. WIDENT - Weather data station identification maximum of six alphameric characters, required only on first card (A4,A2).

C. Problem Decks

CARD #1: Title card format (20A4).

This card contains 80 characters of information used for labeling and identification of all tables, reports and output.

CARD #2: File and indicator variables FORMAT(5A4,10I5,10X).

LOCATION - Alphanumeric array containing identification of the desired location of drying bin. Cross reference against weather data should a mix up occur.

IG - Indicating variable for grain type

1 Yellow Dent Corn

2 Rough Rice

3 Grain Sorghum

4 Soybean Seed

5 Millet Seed

6 Chick-Pea

7 Sesame Seed

8 Groundnut in Pod

9 Wheat Seed

ITALC - Interval of calculation, used as the model time base (HOURS).

I/O JCL must be supplied for these file numbers.

NWTHR - Input file number containing weather data, NWTHR≠NREAD I=NWTHR=0, weather data reused.

I/O JCL must be supplied for these file numbers.

NOUTWR - Output file number for consistent weather data to be written. Default=0

If NOUTWR equal 0, no data is written.

NFILLS - Number of sequential grain files to be placed in bin (1, 2 or 3). (DEFAULT=1)

NTHICK - Desired layer thickness to be used in mathematical model (inches). If blank, 30 layers are assumed and thickness calculated, based on full bin.

NOTE: I/O JCL must be supplied for these file numbers.

NVALID - File number of tape drive on which validation data will be written. JCL must be supplied when used. (DEFAULT=0)

If NVALID=0, validation data will not be written.

NOTE: I/O JCL must be supplied for these file numbers.

NTABLE - File number on which intermediate data is printed. JCL must be supplied. DEFAULT=0

If NTABLE equal 0, no intermediate data written.

INOUT - Indicating variable for control of intermediate output. DEFAULT=0

0 - No intermediate output

1 - Top layer of each fill

2 - Data on each layer for each printing increase

IPRINC - Increment of printing (HOUR) DEFAULT=0

Intermediate output printed every IPRINC hours.

CARD #3: Bin management commands FORMAT (2I5,5F10.0,20X)

LDAY - Julian Date (1-365) which grain is loaded into bin. NO DEFAULT

LHR - Clock Time (0-23) Hour that bin is loaded. NO DEFAULT

MW - Average grain moisture wet basis for fill (Real) (percent or decimal). NO DEFAULT

TGN - Average grain temperature (°F) for the fill. NO DEFAULT

FTGRN - Feed of grain added for the fill NO DEFAULT

PDG - Percent damaged grain - stain test (Steele (67)).

DEFAULT = 30%

FM - Fine material - Thrus of 12/64 Screen (percent or decimal).

DEFAULT = 2.5%

NOTE: Card #3 is repeated for each desired sequential grain fill (NFILLS).

CARD #4: Fan management control commands FORMAT(I5,5X,4I5,2F5.0,F10.0,30X).

IC - Desired control method $1 \leq IC \leq 4$. DEFAULT = 1

1 - Continuous aeration - high speed fan only

2 - Timer controlled aeration, High, Low, Off

3 - Humidistat controlled aeration, High, Low, Off

4 - #2 and 3 combined with #3 given priority

FON - Hour of the day (0-23) when the fan is turned on low speed from being off. (Integer)

FHI - Hour of the day (0-23) when the fan is turned on high speed from being on low. (Integer)

FLOW - Hour of the day (0-23) when the fan is turned on low speed from being on high. (Integer)

FOFF - Hour of the day (0-23) when the fan is turned off from being on low speed. (Integer)

RSHFT - Relative humidity control point (decimal or percent) above which fan operates on low speed, below which the fan operates on high speed.

RHOFF - Relative humidity control point (decimal or percent) above which fan is off, below which the fan operates on low speed.

ADHEAT - Amount of added heat by the use of a supplemental heater, (BTU/HR).

CARD #5: High speed fan curve identification and data.

General fan curve: $SP=A+BQ+CQ^2$ FORMAT(5A4,5F10.0,10X).

FANIDH - High speed fan identification - 20 alphameric characters.

FAN(2,1) - High speed fan curve coefficient A.
DEFAULT = 0

FAN(2,2) - High speed fan curve coefficient B.
DEFAULT = 0

FAN(2,3) - High speed fan curve coefficient C.
DEFAULT = 0

FANEFF - Fan efficiency - mechanical efficiency (demical or percent). DEFAULT = 50%

CARD #6: Low speed fan curve identification and data

FORMAT(5A4,5F10.0,10X)

FANIDL - Low speed fan identification - 20 characters.

FAN(1,1) - Low speed fan curve coefficient A.
NO DEFAULT

FAN(1,2) - Low speed fan curve coefficient B.
DEFAULT = 0

FAN(1,3) - Low speed fan curve coefficient C.
DEFAULT = 0

FANEFF - Low speed fan efficiency (demical or percent).
DEFAULT = 50%

CARD #6 is required for two speed fan management.

4.3 Output from the Program

Output from the program consists of four sections.

Section 1: Weather Data and Identification.

This section includes the weather station identification and an exact reprint in card image form of the weather data as read by DATAIN subroutine from file NWTHR. The second portion is the weather data printed out with the time pointer in a display form, listing dry bulb, relative humidity and atmospheric pressure with the Lagrangian Time Base (day*24+HR). The third and final portion is the resulting homogeneous weather data with no missing data points at the desired interval of calculation (ITCALC). This data is then communicated to the time subroutine to begin the modeling process.

Section 2: Initial model conditions as selected by the user are displayed in tabular form by subroutine TABLE.

This section identifies:

1. The type of grain to be stored and initial conditions
2. The fan sizes and configuration
3. The bin management procedures, when and how much grain is loaded in the drying bin
4. The fan management procedures, which indicate the time and amount of drying or aeration to take place as well as the energy required for each combination.

Section 3: Intermediate Output (user controlled, subroutine OUTPUT).

Grain conditions are monitored and displayed at the desired printing increment (IPRINC). The quantity of output is controlled by the intermediate output variable (INOUT). Also, data tape files are created on file (NVALID) if an experimental validation study is desired, this type file is then upward compatible with the Lagrangian AOV difference table program (LAGRANGE). (For more information see Chapter 1, M.S. Thesis, Samuel G. Maurer.)

Section 4: Final Model Results (Subroutine REPORT).

When the grain has been successfully dried ($M_W \leq$ DRYM(IG) or the grain has deteriorated below marketable levels (DMLOSS $\geq$ 0.5%), or all supplied weather data used, a final report is generated. This final report is identified with the user supplied title of the study (T), followed by the average, maximum and occurring layer for grain moisture content and percent dry matter loss. Hours of fan operation are given in a table for each combination of speed (IS) and FILLS(IFILL). Then an accounting of the energy consumption of the study, which includes the fan energy. Heater supplied energy and total energy required for the experiment.

4.4 Multiple Runs

Several problem decks can be run during the same job step. Sufficient time should be allowed on the Job card, and appropriate JCL for any intermediate output.

5. DRYING SIMULATION

As it has been reviewed above, drying system performances by natural air are mainly affected by the following factors: 1) initial grain moisture content, 2) airflow rate used, and 3) weather conditions. In this study, all of these factors were considered as well as the variability of yearly weather in five areas of Kansas. In the following three sections, a list of assumptions and parameters, criteria used for evaluating the results, fan selection and the drying systems tested are discussed.

5.1 Assumptions and Parameters

In order to calculate the total airflow rate a bin 18 feet in diameter was taken as the model. The assumptions and parameters tested were:

1. A single-fill and continuous fan operation.
2. Conditions of grain sorghum

   Initial moisture contents: 21.0, 18.0 and 16.0% w.b.

   % Damage (stain-test, Steele, 1969): 25%

   % Fine material: 12%

   Number of modeled layers: 10
3. Grain temperatures for the different districts were estimated on the basis of weather data about the time of drying.
4. The study areas were chosen according to the importance in grain sorghum production (see Table 1). They are: Topeka, Dodge City, Wichita, Concordia and Goodland. Official weather data was collected in intervals of 3 hours during 11 years (1963-1973) for the chosen areas, but for the simulation purposes only 3 years were selected as is shown in Table 7. The selection of these 3 years was made on the basis of the temperatures and relative humidities from 11 years for each chosen weather station (see

Figure 2). The chosen years were classified as: year relatively hot and dry, year of average temperature and average relative humidity, and year relatively cold and humid.

Table 7. Weather data stations, periods and years examined.

Station	Period Tested	Year Relatively Hot and Dry	Year of Average Temperature and Average Relative Humidity	Year Relatively Cold and Humid
Topeka	Oct. 5 to Nov. 15	1963	1965	1972
Dodge City	Oct. 20 to Nov. 30	1963	1971	1972
Wichita	Oct. 15 to Nov. 25	1963	1968	1972
Concordia	Oct. 15 to Nov. 25	1963	1968	1972
Goodland	Oct. 20 to Nov. 30	1963	1966	1969

5.2 Fan Selection

Fan was selected for each particular combination of grain depth and airflow rate required. The procedure was followed according to the computer program guide:

The fan static pressure equation is

FANSP(Q) = FA + FB*Q + FC*Q*Q

where

FANSP(Q) = static pressure at the fan outlet, inches of water/foot

Q = airflow rate/area, cfm/ft^2

FA,FB,FC = constants for the selected fan.

To find FA, FB, and FC, it must follow the following procedure:

1. Select a fan of a given speed which is to be used.
2. Perform a regression analysis of the data for this fan to obtain the constants for the equation of the form:

$$SP = A + BV + CV^2$$

where

SP = static pressure, inches of water

V = airflow rate, cfm

A,B,C = constants

Since Q = V/Area of bin

$$SP = A + B*Q*Area + C*Q^2*(Area)^2$$

or

$$FA = A$$

$$FB = B*Area$$

$$FC = C*(Area)^2$$

The formula for static pressure drop for grain sorghum in the computer program is:

$$GRNSP(Q) = 0.0249531Q + 0.000389805Q^2 - 0.0020691QF$$

where:

GRNSP(Q) = static pressure drop, inches of water/ft.

Q = airflow rate/area, cfm/ft^2

F = fine material, decimal

For a fixed airflow rate according to the statement of the program: "when fan static pressure equals the grain pressure, then the airflow of the system will be equal to Q for those combinations of depth, fan curve, grain curve," FA values were taken at these conditions in order to get the airflow rate required. FB, FC and fan efficiency were assumed to be zero, zero, and 0.50 respectively.

5.3 Criteria of Failure or Success

Dry matter loss was primarily taken as criteria of failure or success but for the purposes of evaluation, final moisture content distribution and drying time were also considered as the limiting factors of the failure or success of the drying system tested. A dry matter loss greater than 0.5 percent was accepted as failure of the operating conditions.

It was estimated that a desirable final average moisture content of less than 14% (w.b.) with extremes no greater than 15½% (w.b.) and no less than 10% (w.b.) are necessary to avoid overdrying, i.e., to have a successful operation, drying front must reach the top and all grain must be dried before it is spoiled.

5.4 Drying Systems Tested

Table 8 shows the combinations of system performance factors for each year and area tested.

Table 8. Combinations of system performance factors tested.

Initial Moisture Content % w.b.	Airflow Rates, cfm/bu						
	¼	½	3/4	1	1½	2	2½
21	X	X		X	X	X	X
18	X	X	X	X	X	X	
16	X	X	X	X	X		

5.5 Procedures

The general procedure of the simulations consisted of:

1. To fix a combination of initial grain moisture content and airflow rate and run the program for various possible grain depths for each chosen year and each area to be tested.

2. To evaluate the computer output according to the model noted in section 5.2, i.e., to accept as a successful drying system if the dry matter loss was less than 0.5% and extremes of moisture content were less than 15.5% and greater than 10% with an average of 14%. When the drying system was not successful, then a lower grain depth was tested and so on. But if the drying system was still unsuccessful, then, a higher airflow rate was tried. The procedure was repeated until the result was successful.

5. RESULTS FROM SIMULATIONS AND DISCUSSION

The simulation results were evaluated according to the designed model discussed in section 5.3. Drying time was determined when the conditions of grain moisture content were satisfactory to the model. An example of this determination is shown in Figure 3.

In addition, the effects of airflow rate, initial moisture content, yearly weather conditions, and location on the grain drying performance were observed and discussed under the consideration of the general and specific objectives of this study.

The results summarized in Tables 9, 10, and 11, are the successful tested drying systems for three years of weather data of the five weather stations studied. Table 9 shows the successful results for 21% w.b. initial grain moisture content; in this table, it can be seen that for the same grain depth and airflow rate, it needs less time for a year relatively hot and dry than for a year of average temperature and average relative humidity (year not hot and not very humid). But, for a year relatively cold and humid, it needs higher airflow rate and lower grain depth to get a successful result. Table 10 shows the results for 18% w.b. initial grain moisture content, and Table 11 shows the results for 16% w.b. initial grain moisture content. Both tables show the same situation, i.e. it needs more time for a year not hot and not very humid than for a year relatively hot and dry and, again it needs higher airflow rate, lower grain depth and almost the same drying time for a year relatively cold and humid.

The required energy for the fan in Tables 9, 10, and 11, also show that the largest energy consumption is required in a year relatively cold and humid because, it needs a higher airflow rate and almost the same time

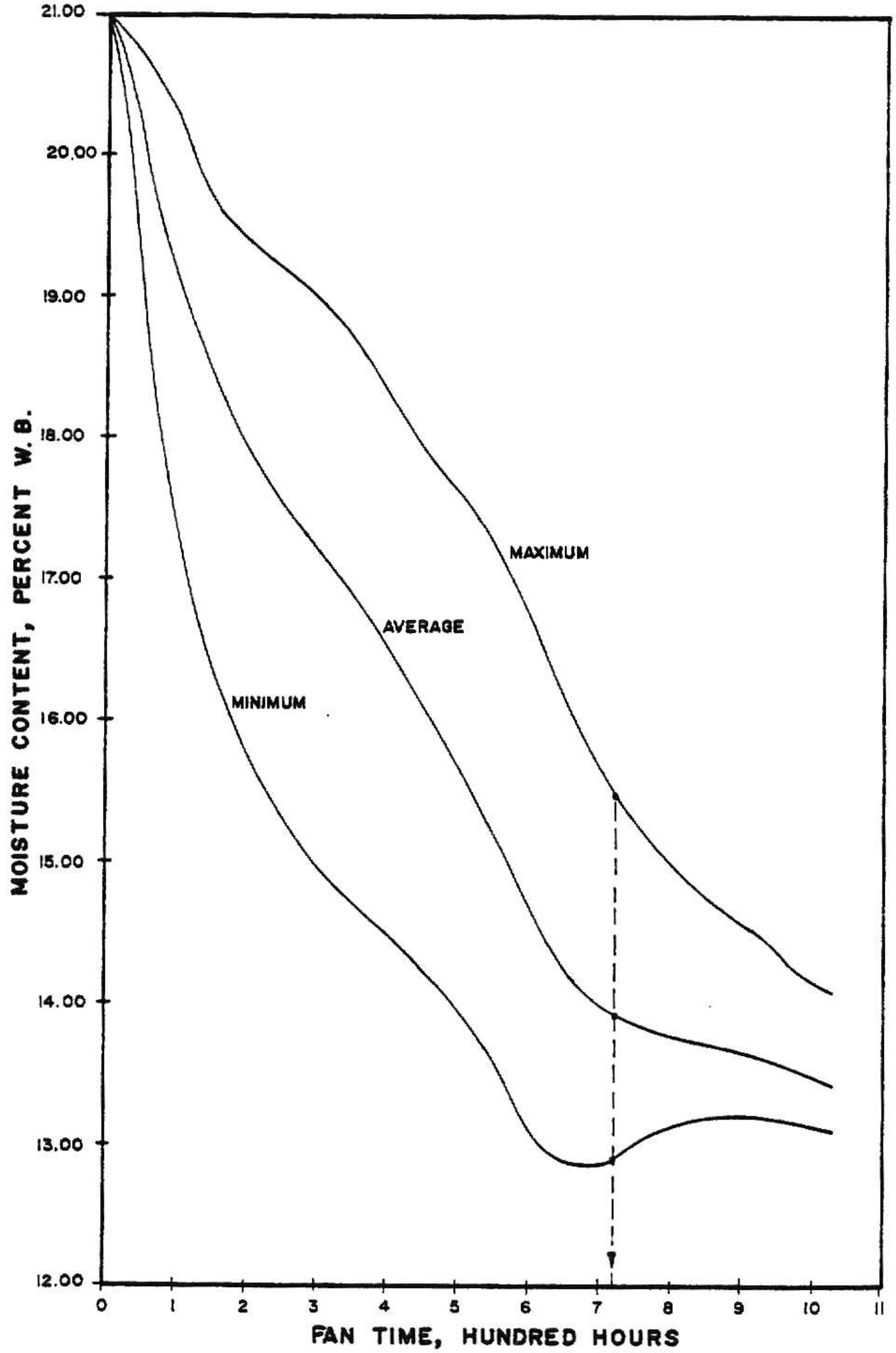

Figure 3. Fan time determination model in grain sorghum drying. 21% initial moisture content, 16.7 feet bed depth, 1½ cfm/bu airflow rate. Wichita Area, starting date: October 15, 1972.

Table 9. Successful grain sorghum drying systems by natural air for five areas of Kansas. Three years of weather data.

Criteria: Initial grain moisture content 21% w.b. DML < 0.5%
Final average moisture content 14% w.b.
Final maximum moisture content 15.5% w.b.

Location	Year Relatively Hot and Dry	Year Not Hot and Not Very Humid	Year Relatively Cold and Humid
Topeka Area			
Starting date: Oct. 5	1963	1965	1972
Airflow rate, cfm/bu	1	1	1
Grain depth, ft	20.8	20.8	16.7
Fan time, hrs	441	645	942
Ave. M.C., % w.b.	12.74	12.68	13.98
Energy used, KwH	4,826	7,059	5,122
Dodge City Area			
Starting date: Oct. 20	1963	1971	1972
Airflow rate, cfm/bu	1	1	1½
Grain depth, ft	16.7	16.7	16.7
Fan time, hrs	747	1,005	645
Ave. M.C., % w.b.	13.53	13.80	13.66
Energy used, KwH	4,061	5,464	8,572
Wichita Area			
Starting date, Oct. 15	1963	1968	1972
Airflow rate, cfm/bu	1	1	1½
Grain depth, ft	16.7	16.7	16.7
Fan time, hrs	807	1,029	723
Ave. M.C., % w.b.	13.07	13.71	13.88
Energy used, KwH	4,388	5,595	9,609
Concordia Area			
Starting date: Oct. 15	1963	1968	1972
Airflow rate, cfm/bu	1	1	2
Grain depth, ft	16.7	16.7	15.0
Fan time, hrs	804	1,029	597
Ave. M.C., % w.b.	13.32	13.85	13.96
Energy used, KwH	4,371	5,595	10,796
Goodland Area			
Starting date: Oct. 20	1963	1966	1969
Airflow rate, cfm/bu	1	1	1½
Grain depth, ft	16.7	16.7	15.0
Fan time, hrs	819	918	777
Ave. M.C., % w.b.	13.47	13.53	13.47
Energy used, KwH	4,453	4,991	7,301

Table 10. Successful grain sorghum drying systems by natural air for five areas of Kansas and estimated fan times and final average grain moisture contents. Three years of weather data.

Criteria: Initial grain moisture content 18% w.b. DML < 0.5%
Final average moisture content 14% w.b.
Final maximum moisture content 15.5% w.b.

Location	Year Relatively Hot and Dry	Year Not Hot and Not Very Humid	Year Relatively Cold and Humid
Topeka Area			
Starting date, Oct. 5	1963	1965	1972
Airflow rate, cfm/bu	½	3/4	3/4
Grain depth, ft	17.5	18.3	18.3
Fan time, hrs	753	651	822
Ave. M.C., % w.b.	13.50	13.47	13.93
Energy used, KwH	1,081	2,523	3,186
Dodge City Area			
Starting date, Oct. 20	1963	1971	1972
Airflow rate, cfm/bu	3/4	3/4	1
Grain depth, ft	18.3	18.3	18.3
Fan time, hrs	645	771	600
Ave. M.C., % w.b.	13.22	13.62	13.84
Energy used, KwH	2,500	2,988	4,366
Wichita			
Starting date, Oct. 15	1963	1968	1972
Airflow rate, cfm/bu	3/4	3/4	1
Grain depth, ft	18.3	18.3	18.3
Fan time, hrs	663	669	1,020
Ave. M.C., % w.b.	13.74	14.02	14.00
Energy used, KwH	2,569	2,593	7,422
Concordia Area			
Starting date, Oct. 15	1963	1968	1972
Airflow rate, cfm/bu	3/4	3/4	1½
Grain depth, ft	18.3	18.3	16.7
Fan time, hrs	666	1,029	642
Ave. M.C., % w.b.	13.57	13.72	13.66
Energy used, KwH	2,581	3,988	8,532
Goodland Area			
Starting date, Oct. 20	1963	1966	1969
Airflow rate, cfm/bu	3/4	3/4	1
Grain depth, ft	18.3	18.3	16.7
Fan time, hrs	666	726	702
Ave. M.C., % w.b.	13.25	13.52	13.82
Energy used, KwH	2,581	2,813	3,817

Table 11. Successful grain sorghum drying systems by natural air for two areas of Kansas and estimated fan times and final average of grain moisture contents. Three years of weather data.

Criteria: Initial grain moisture content 16% w.b. DML < 0.5%
Final average moisture content 14% w.b.
Final maximum moisture content 15.5% w.b.

Location	Year Relatively Hot and Dry	Year Not Hot and Not Very Humid	Year Relatively Cold and Humid
Wichita Area			
Starting date: Oct. 15	1963	1968	1972
Airflow rate, cfm/bu	½	½	3/4
Grain depth, ft	20.8	22.5	20.8
Fan time, hrs	567	663	747
Ave. M.C., % w.b.	13.96	13.60	13.95
Energy used, KwH	1,393	2,065	4,339
Concordia Area			
Starting date: Oct. 15	1963	1968	1972
Airflow rate, cfm/bu	½	½	1
Grain depth, ft	20.8	22.5	18.3
Fan time, hrs	576	645	621
Ave. M.C., % w.b.	13.90	13.59	14.00
Energy used, KwH	1,415	2,009	4,519

required when the year is hot and dry. It can be also observed in these tables, that the highest airflow rate and the largest energy consumption were required for the Concordia Area.

The obtained results can be compared roughly to the results already shown in Table 6. From this comparison it can be said that there are reasonable differences in time and energy used. For example, comparing data for Wichita Area, 1972--Table 9 to the data of bin #1--Table 6, the differences in airflow rate and time are reasonable considering that these tables differ in the kind of grain, amount of grain and weather data. In general it is observed that less energy and time requirements are needed for the area of Kansas than for the area of Des Moines, Iowa.

The Effect of Weather Conditions

Figures 4, 5 and 6, illustrate the differences in grain deterioration (expressed as percentage of dry matter loss) which can occur in the drying process as due to weather conditions in different years previously chosen: relatively hot and not humid (1963); relatively not hot and not very humid (1968); and relatively cold and humid (1972). The results showed that there is a higher dry matter loss in a relatively hot year (1963), which is explained by the temperature dependence of the combustion process of a typical carbohydrate, hexose with the reaction represented by the following equation:

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + 677.2 \text{ kg cal}$$

As it is shown in these figures, dry matter losses were considerably less for years 1968 and 1972. Thus, the dry matter loss in a relatively hot and dry year (1963) was as large as two-fold more than the dry matter loss in an average year (1968) and more than two-fold in a cold and humid year (1972). These results show that year-to-year weather conditions may be responsible for the differences in dry matter loss.

Effect of Airflow Rate

Figures 4, 5 and 6 also show the effct of airflow rate on dry matter loss for 3 different weather conditions in Wichita, Kansas. The highest dry matter loss was shown for the lowest airflow rate used. For the year in which the air temperature was generally low (1972), the dry matter loss was not significantly affected by the airflow rates applied. Figures 7, 8 and 9 show the effect of airflow rate on the final maximum grain moisture content. These figures show that to obtain a desirable moisture content at the top layer, less time is required when a higher airflow rate is

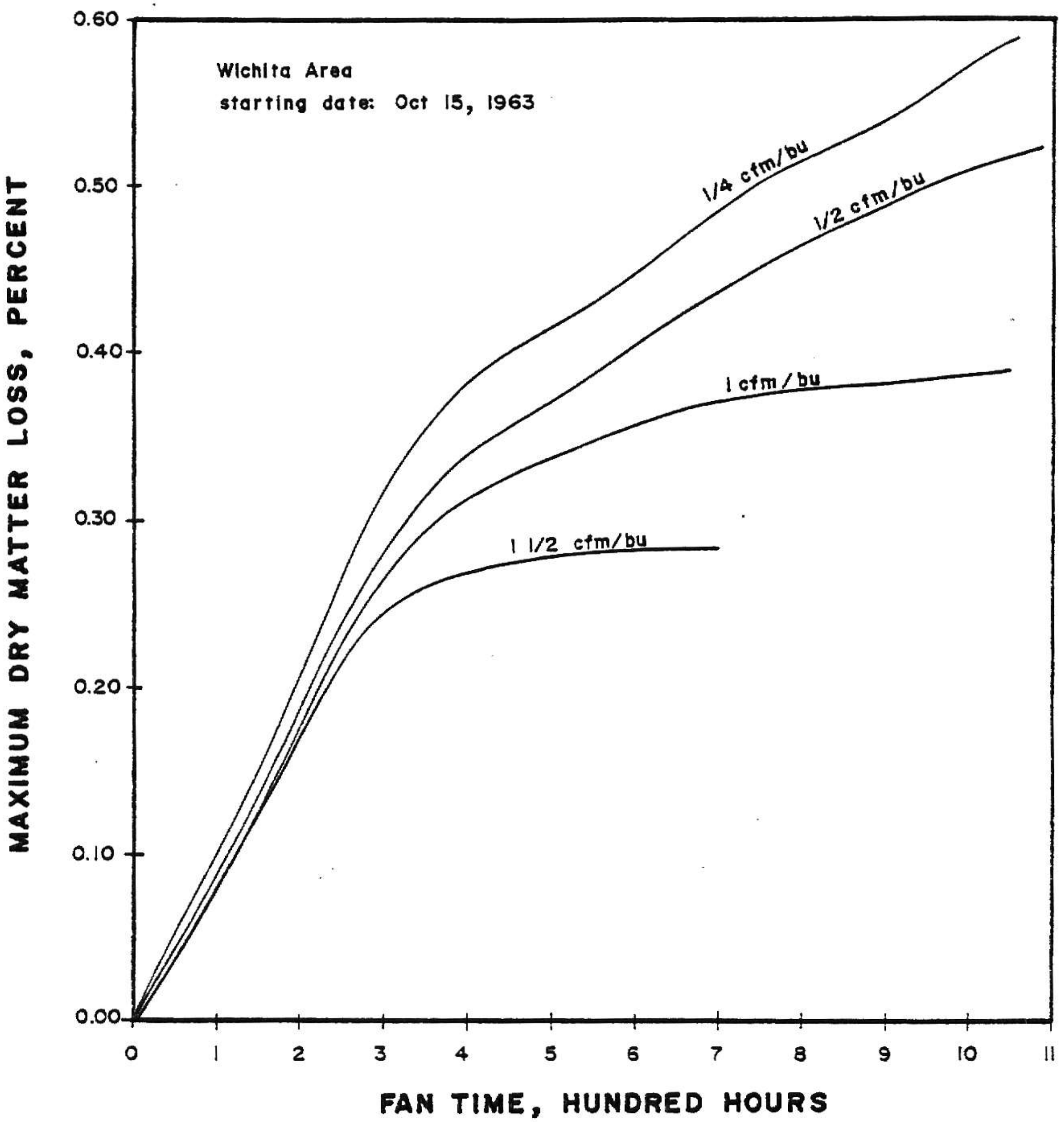

Figure 4. Effect of airflow rate on dry matter loss in grain sorghum drying. 21% (w.b.) initial moisture content and 16.7 feet bed depth.

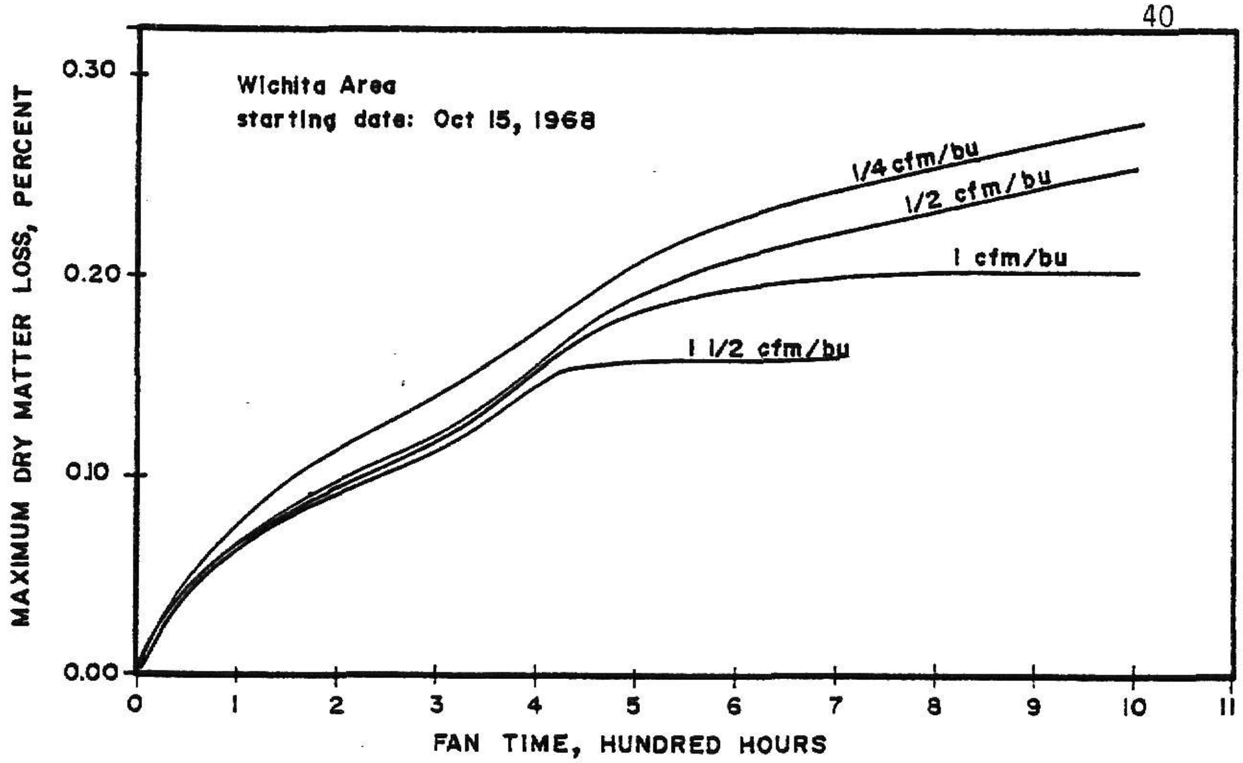

Figure 5. Effect of airflow rate on dry matter loss in grain sorghum drying. 21% (w.b.) initial moisture content and 16.7 feet depth.

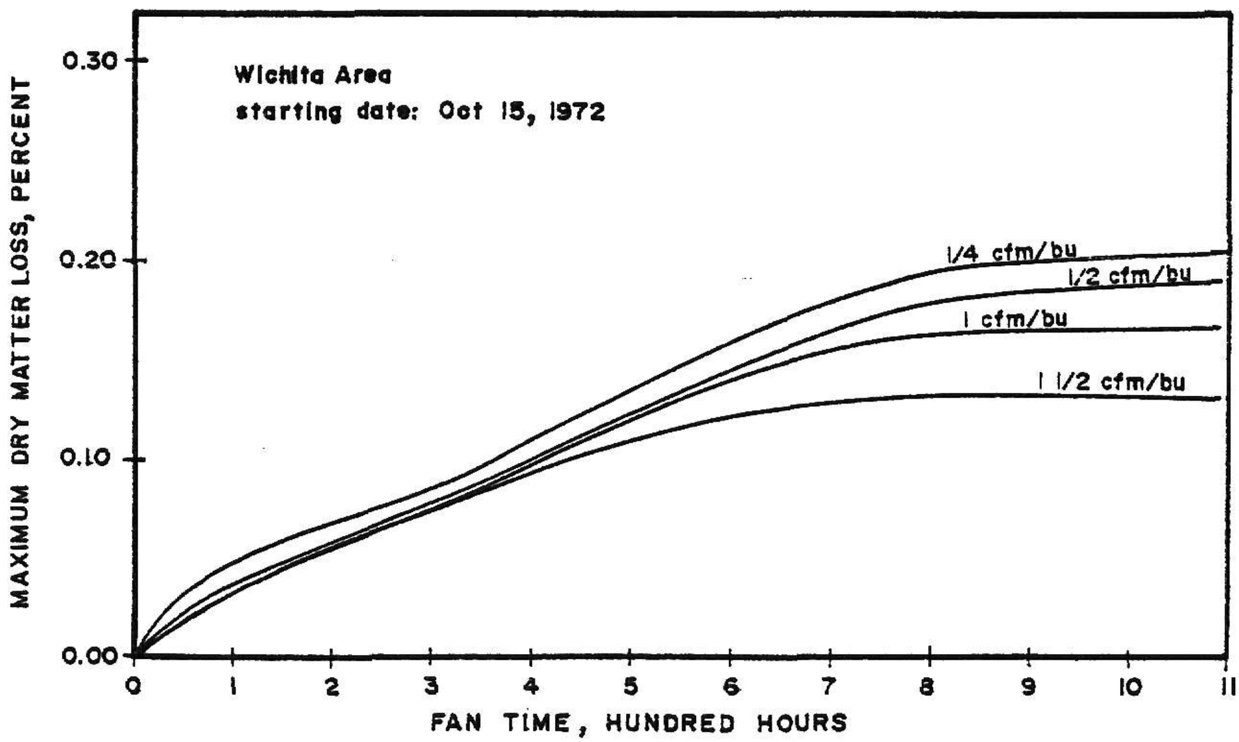

Figure 6. Effect of airflow rate on dry matter loss in grain sorghum drying by natural air. 21% (w.b.) initial moisture content and 16.7 feet bed depth.

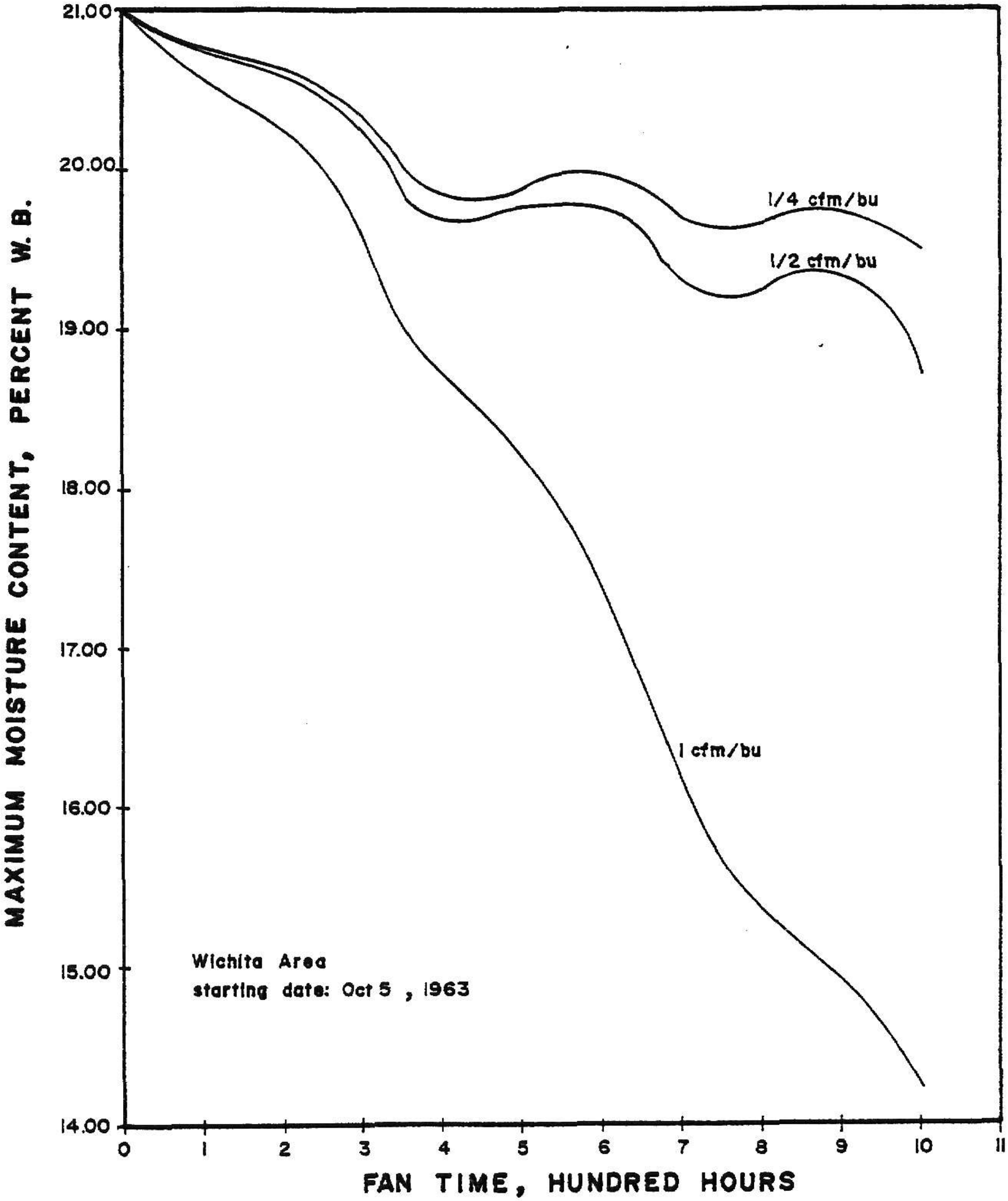

Figure 7. Effect of airflow rate on moisture content in grain sorghum drying. 21% (w.b.) initial moisture content, 16.7 feet bed depth.

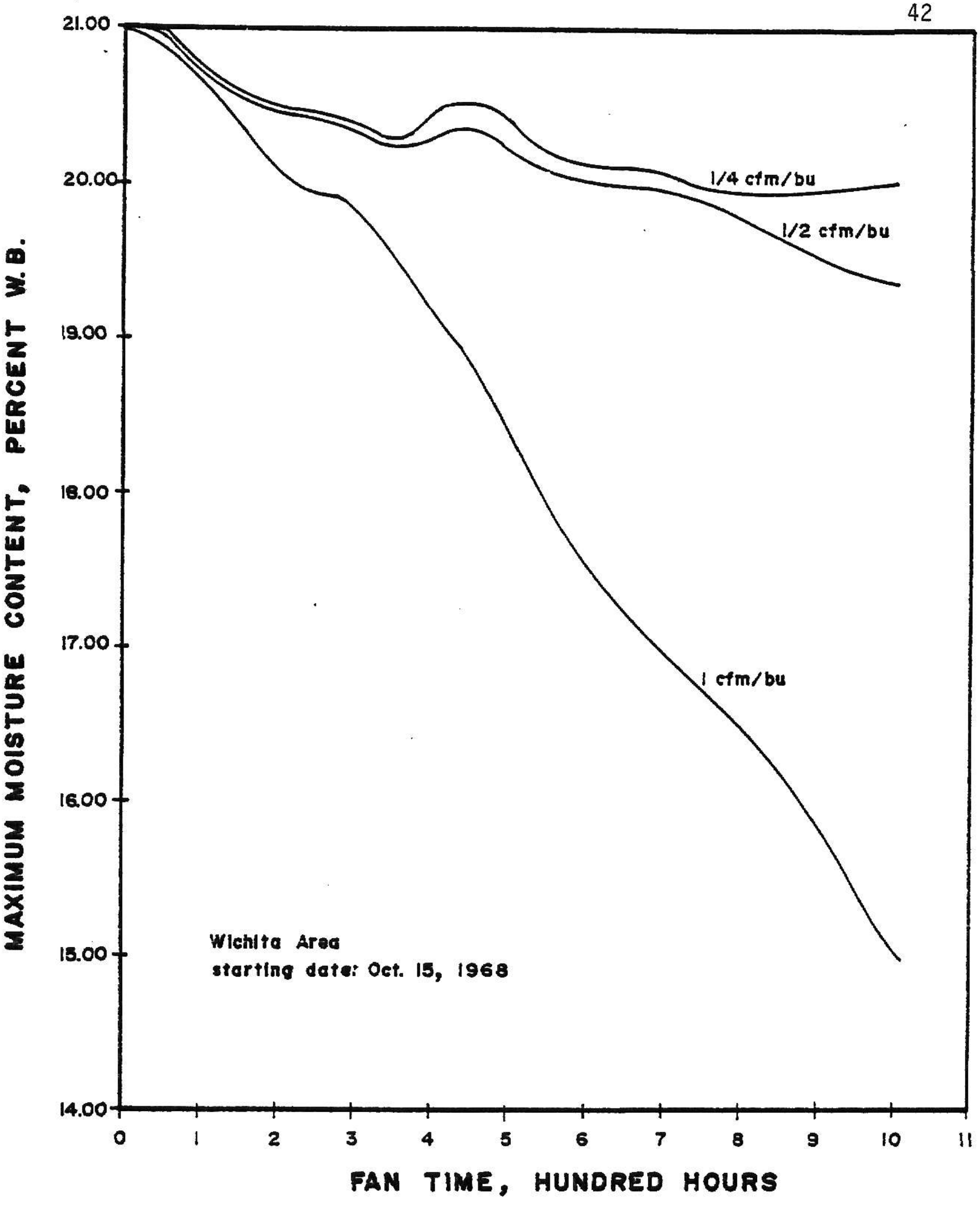

Figure 8. Effect of airflow rate on moisture content in grain sorghum drying. 21% (w.b.) initial moisture content, 16.7 feet bed depth.

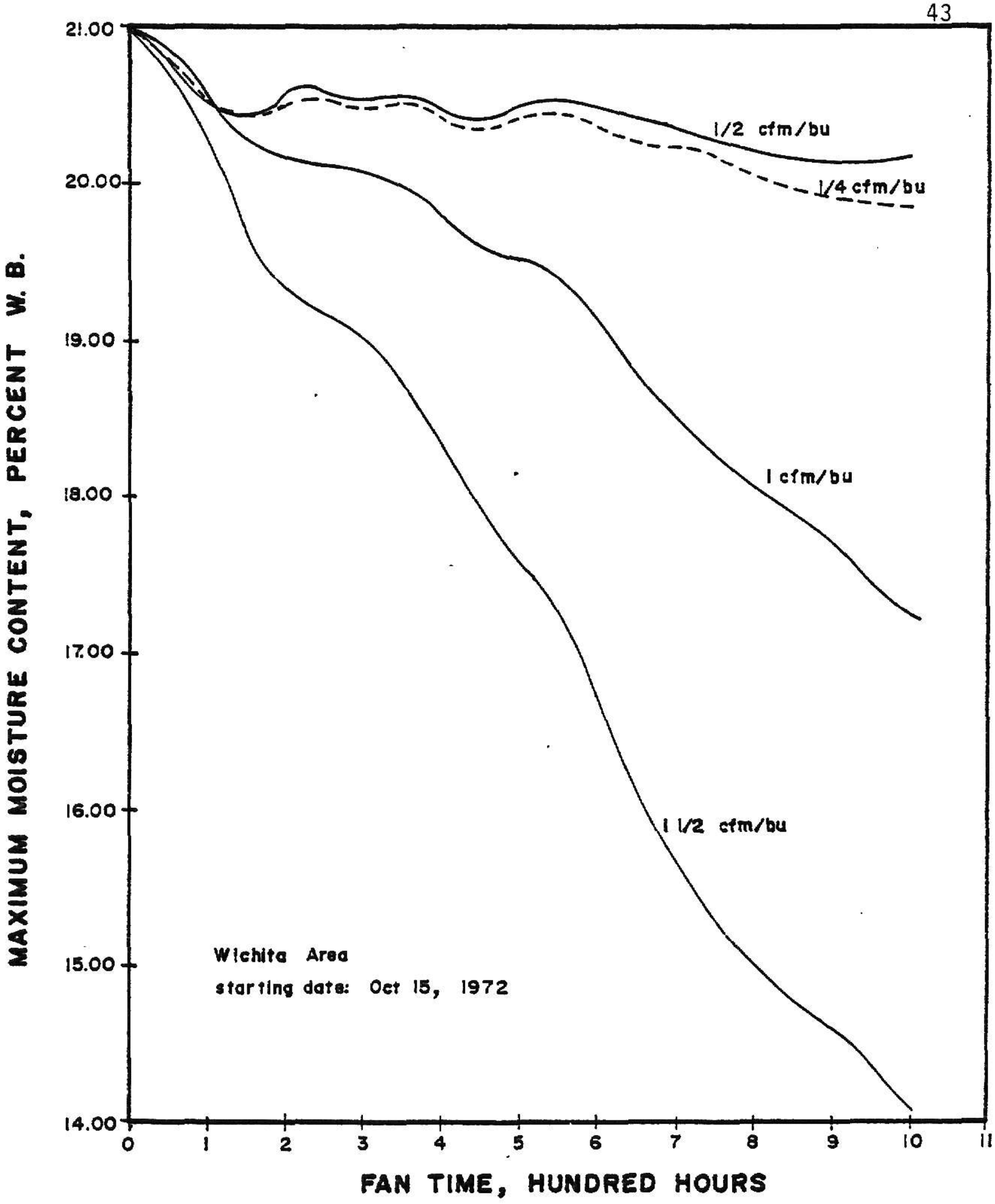

Figure 9. Effect of airflow rate on moisture content in grain sorghum drying. 21% (w.b.) initial moisture content, 16.7 feet bed depth.

used, although these differences can vary considerably for different weather conditions as is observed in Figure 9. In general, from Figures 7, 8 and 9, it is shown that the longer the drying time, the larger the differences in the final grain moisture content for the different airflow rates.

Figure 10 shows the effect of airflow rate on the final dry matter loss distribution along a given grain depth. The results show that the larger dry matter losses can occur at the top layer with the losses being even greater at lower airflow rates. Finally in Figure 11, the effect of airflow rate on the final moisture content distribution is shown. As can be observed for the depth studies, better moisture content distribution is shown for higher airflow rates, although this is not always true because this distribution depends highly on the grain depth and initial moisture content.

Effect of Initial Moisture Content

The effect of initial moisture content on dry matter loss along a given depth is shown in Figure 10. It can be observed that a larger dry matter loss occurs in drying of grain with a higher initial moisture content. The gradient in dry matter loss between the top and the bottom of the bin was also higher in grain with a higher initial moisture content and with the highest dry matter losses at the upper layers of the grain depth.

The other important effect of initial moisture content on the drying performance was its effect on the final moisture content distribution. In Figure 11, it can be observed that a better distribution occurs in the drying of grain with the lowest initial moisture content.

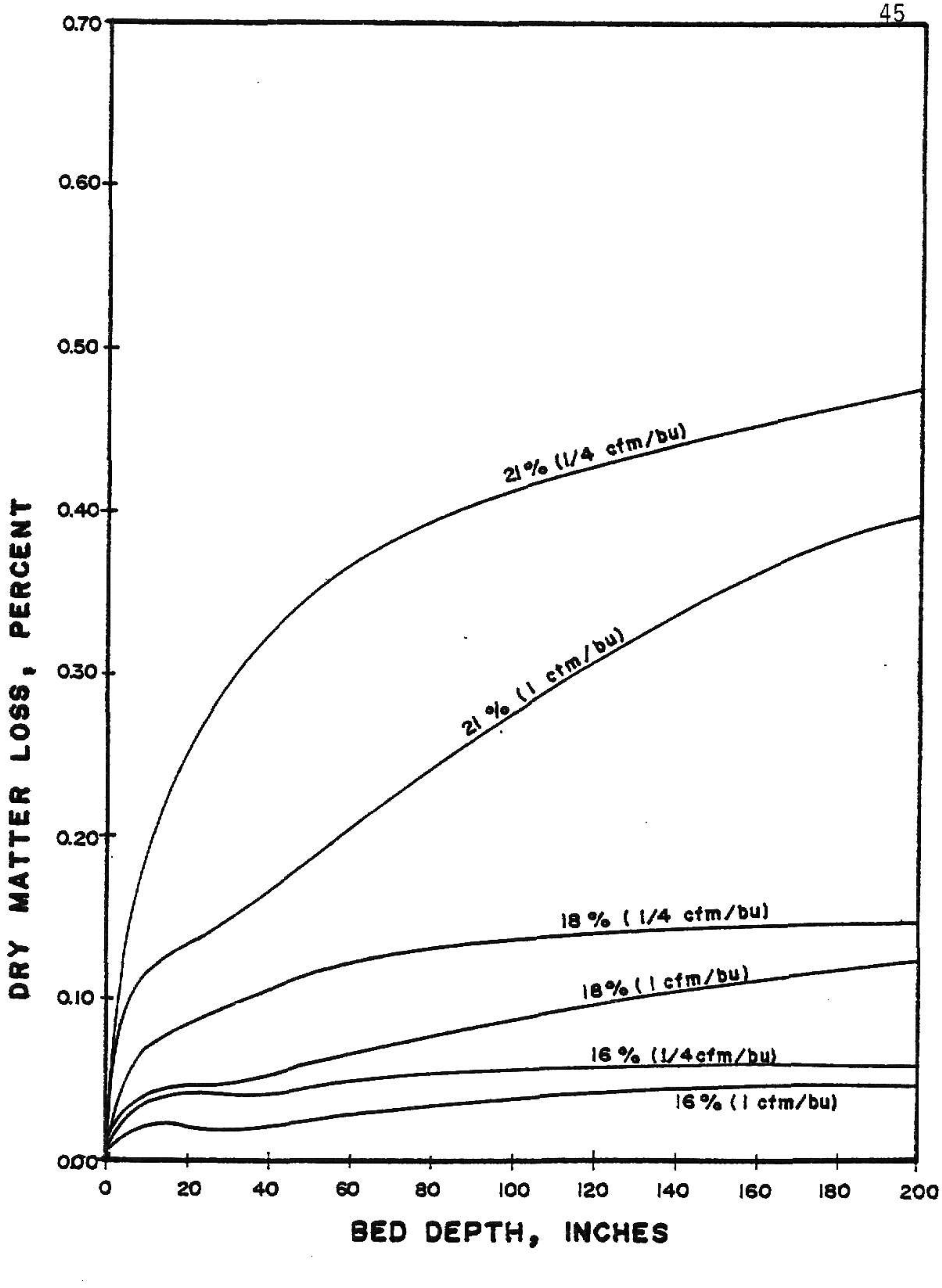

Figure 10. Effect of initial moisture content and airflow rate applied on the final dry matter loss distribution at 645 hours of drying time along 16.7 feet bed depth of grain sorghum. Wichita Area, started on October 15, 1963.

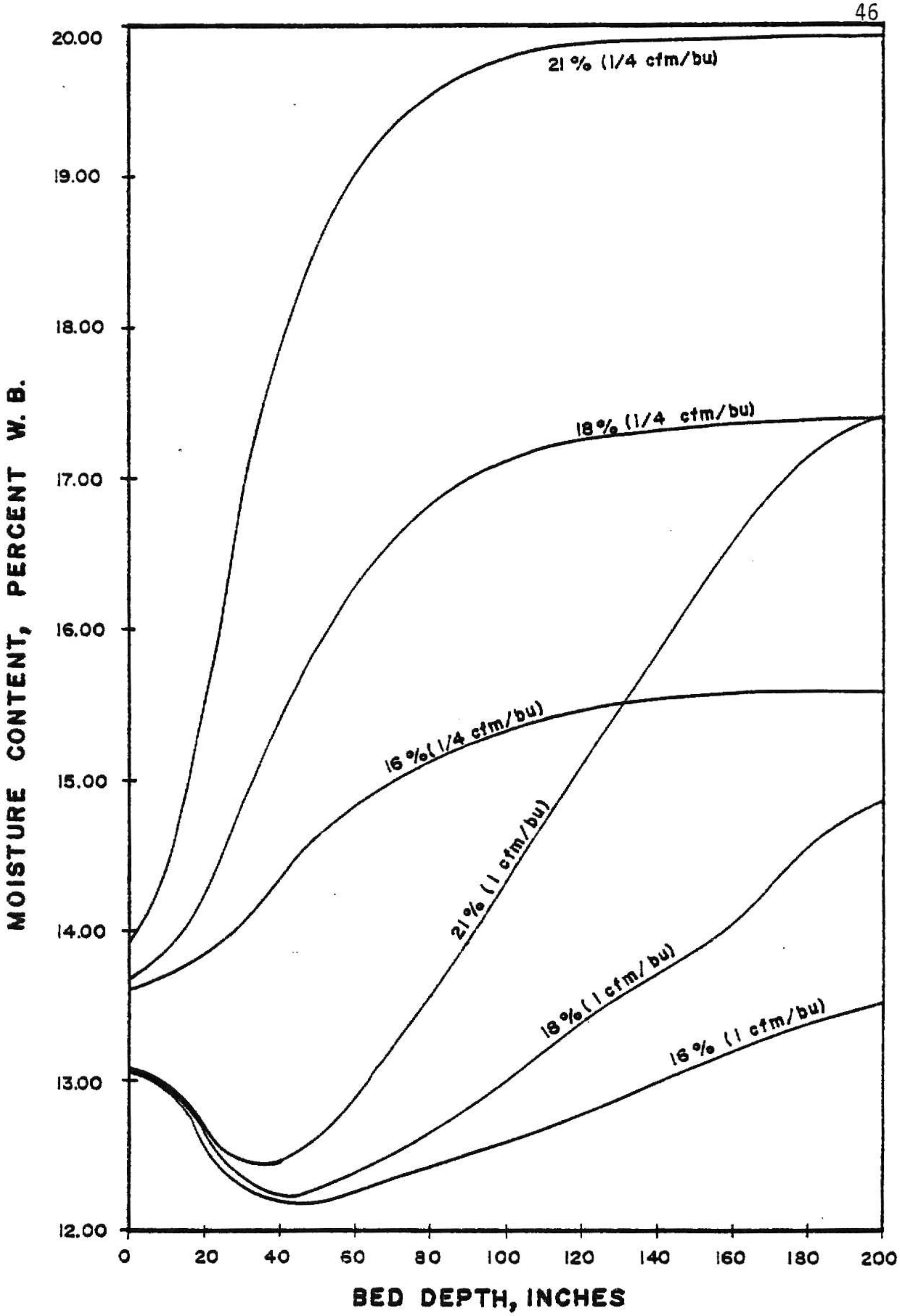

Figure 11. Effect of initial moisture content and airflow rate on the final moisture content distribution at 645 hours of drying time and 16.7 feet bed depth of grain sorghum. Wichita Area, started on October 15, 1963.

Higher moisture content was always at the upper layers and the lowest was near or at the bottom depending on air conditions which can rewet the grain if it was not within the drying requirement.

Recommended Grain Sorghum Drying Systems by Natural Air

From the simulation results shown in Tables 9, 10 and 11, it was possible to construct Table 12 for recommending grain sorghum drying systems by natural air for the different areas of Kansas. Table 12 also shows a comparison between USDA recommendations and KSUDRYER recommendations. In this table, when weather data of a relatively cold and humid year was used, USDA recommendations of airflow rate and grain depth were a little closer to the KSUDRYER recommendations, but when weather data of a hot and dry year or an average year was used, then the differences were larger and USDA recommendations look like very conservative drying systems.

Another important observation is that, when weather data of a relatively hot and dry year was used, the resulting values of the recommended drying systems were the same for all of the Kansas districts.

Thus, in general this table shows lower airflow rates and higher grain depths than the recommended USDA values under the Kansas weather.

Table 12. Recommended grain sorghum drying systems by natural air in Kansas

Initial Moisture Content (% w.b.)	U.S. Dept. of Agriculture		KSU DRYER (SORGMDRY)							
			WC, NW, NC and NE Districts				SW, SC, SE, C and EC Districts			
			Rel. Hot-Dry Year		Rel. Cold-Wet Year		Rel. Hot-Dry Year		Rel. Cold-Wet Year	
	Minimum Airflow Rate (cfm/bu)	Maximum Depth (ft)	Airflow Rate (cfm/bu)	Max. Depth (ft)	Airflow Rate (cfm/bu)	Max. Depth (ft)	Airflow Rate (cfm/bu)	Max. Depth (ft)	Airflow Rate (cfm/bu)	Max. Depth (ft)
21			1	16	2	15	1	16	1½	16
20	3	8								
18	2	10.5	3/4	18	1½	16	3/4	18	1	18
16	1	16	½	22	1	18	½	22	3/4	20

7. SUMMARY AND CONCLUSIONS

A series of drying systems were simulated to evaluate the drying performance in grain sorghum drying by natural air. The effects of yearly weather conditions, airflow rate and initial moisture content on the drying performance were analyzed. Also, grain depth was examined as a limiting factor to get a desirable final moisture content distribution. Drying simulations were made for three years and for five different weather stations: Topeka: 1963, 1965 and 1972, Dodge City: 1963, 1971 and 1972, Wichita: 1963, 1968 and 1972, Concordia: 1963, 1968 and 1972, and Goodland: 1963, 1966 and 1969. Tests were run for three initial moisture contents and various airflow rates and grain depths.

Based on an analysis of results obtained from the digital computer simulations the following conclusions were formulated for natural air drying systems in Kansas:

1. It is feasible to dry grain sorghum by natural air under Kansas weather conditions using the following drying systems: when a hot-dry year is expected, in all of the Districts of Kansas: for 21, 18 and 16% (w.b.) initial moisture contents, airflow rates of 1, 3/4 and ½ cfm/bu can be used with maximum grain depths of 16, 18 and 22 feet, respectively. But, when a cold-humid year is expected, two regions must be considered: (a) the West Central, Northwest, North Central and Northeast Districts: for 21, 18 and 16% (w.b.) initial moisture contents, airflow rates of 2, 1½ and 1 cfm/bu can be used with maximum grain depths of 15, 16 and 18 feet, respectively; and (b) the Southwest, South Central, Southeast, Central and East Central Districts: for 21, 18 and 16% (w.b.) initial moisture contents,

airflow rates of $1\frac{1}{2}$, 1 and 3/4 cfm/bu can be used with maximum grain depths of 16, 18 and 20 feet, respectively.

2. The amount of grain deterioration (expressed as dry matter loss) during the drying process showed to be a function of the drying air temperature, airflow rate, initial grain moisture content and length of the drying period. Generally, the higher the drying air temperature, initial moisture content, and longer length of the drying period and lower airflow rate, the higher the grain deterioration. Also, deterioration was to be higher at the upper layers.
3. Gradient of final grain moisture content between the top and the bottom can be decreased by decreasing the initial moisture content and bed depth.
4. Changes in yearly weather conditions can drastically change the results of the drying operation.

8. REFERENCES

1. American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc. ASHRAE Handbook and Product Directory 1979 Equipment. Chapter 3.

2. Brooker, D.B., Bakker-Arkema, F.W. and Hall, C.W. 1978. Drying Cereal Grains. The AVI Publishing Co., Westport, Conn.

3. Chang, D.I. 1978. Modeling for Dryer Selection and Simulation of Natural Air Drying of Rough Rice. Master's Thesis, Kansas State University, Manhattan, Kansas.

4. Christensen, C.M. 1974. Storage of Cereal Grains and Their Products. American Association of Cereal Chemists.

5. Converse, H.H., Hodges, T.O. and Sauer, D.B. 1974. Slow Drying of High Moisture Grain Sorghum. ASAE Paper No. 74-3004. ASAE, St. Joseph, Michigan.

6. Converse, H.H., Foster, G.H. and Sauer, D.B. 1978. Low Temperature Grain Drying with Solar Heat. Transac. of the ASAE 21(1): 170-175.

7. Flood, C.A., Sabbah, M.A., Jr., Meeker, D. and Peart, R.M. 1972. Simulation of a Natural-Air Corn Drying System. Transactions of the ASAE 15(1): 156-162.

8. Foster, G.H. 1953. Minimum Air Flow Requirements for Drying Grain with Unheated Air. Agricultural Engineering 34: 681-684.

9. Jackson, D.M., Grant, W.R. and Shafer, C.E. 1980. U.S. Department of Agriculture. U.S. Sorghum Industry. Agricultural Economic Report No. 457.

10. Kansas Crop and Livestock Reporting Service. 1980. Sorghum Acreage and Production by Counties. Topeka, Kansas.

11. Kansas Crop and Livestock Reporting Service. August 1979. Kansas Field Crops from Planting to Harvest. Topeka, Kansas.

12. Maurer, S.G. and Pfost, H.B. 1978. Design of Natural Air Grain Systems. Kansas State University, Food and Feed Grain Institute, Manhattan, KS. Research Report No. 13, Sept. 1978.

13. Maurer, S.G. 1977. Natural-Air Grain Drying--Modeling and Validation. Unpublished Master's Thesis, Kansas State University, Manhattan, Kansas.

14. Morey, R.V., Cloud, H.A., Gustafson, R.J. and Petersen, D.W. 1979. Management of Ambient Air Drying Systems. Transactions of the ASAE 22(6): 1418-1425.

15. Pfost, H.B., Maurer, S.G., Grosh, L.E., Chung, D.S. and Foster, G.H. 1977. Fan Management Systems for Natural Air Drying. ASAE Paper No. 77-35267. ASAE, St. Joseph, Michigan.

16. Saul, R.A. and Lind, E.F. 1958. Maximum Time for Safe Drying of Grain with Unheated Air. Transac. of the ASAE : 29-33.

17. Shedd, C.K. 1953. Resistance of Grains and Seeds to Air Flow. Agricultural Engineering 34: 616-619.

18. Solar Energy subcommittee of the Midwest Plan Service. 1980. Low Temperature and Solar Grain Drying Handbook. MWPS-22. Iowa State University, Ames, Iowa.

19. Steele, J.L., Saul, R.A. and Hukill, W.V. 1969. Deterioration of Shelled Corn as Measured by Carbon Dioxide Production. Transac. of the ASAE 12(5): 685-689.

20. Thompson, T.L. 1972. Temporary Storage of High-Moisture Shelled Corn Using Continuous Aeration. Transac. of the ASAE 15(2): 333-337.

21. United States Department of Commerce. National Oceanic and Atmospheric Administration, Environmental Data Service. Local Climatological Data, Narrative Climatological Summaries. Weather Data Library. Kansas Agricultural Experiment Station, Manhattan, Kansas.

APPENDIX A

Results of Simulations Performed

Table A.1. Simulation Results for Topeka Station

Year : 1963
Period: Oct. 5-Oct. 31
JDAY : 278

Grain Temp: 63
% Damage : 25
% Fine Mat: 12

Input					Output					Observation
					% Moisture Content					
L. Thickness, in	% Initial Moist. Cont.	Depth, ft	Fan Constant, FA	Airflow, cfm/bu	Ave	Bottom (Min.)	Top (Max.)	% DML Max	Drying Time, hrs	Failure or Success
30	21.0	25.0	3.3513	¼	17.70	12.65	19.78	0.6152	645	F
25	21.0	20.8	4.8877	½	15.40	12.57	19.26	0.3276	645	F
25	21.0	20.8	10.9009	1	12.74	11.60	15.47	0.2524	441	S*
30	21.0	25.0	27.4999	1½	14.00	9.18	18.24	0.1135	135	F
20	21.0	16.7	10.9916	1½	12.53	10.82	15.45	0.1445	291	S
21	18.0	17.5	3.3943	½	13.73	12.45	15.99	0.1538	645	F
21	18.0	17.5	3.3943	½	13.50	12.35	15.50	0.1577	753	S*
25	18.0	20.8	10.9009	1	12.50	10.26	15.51	0.0568	267	S
21	18.0	17.5	7.4628	1	12.93	11.12	15.48	0.0587	291	S

Table A.2. Simulation Results for Topeka Station

Year : 1965
Period: Oct. 5-Oct. 21
JDAY : 278

Grain Temp: 55
% Damage : 25
% Fine Mat: 12

Input					Output					Observation
					% Moisture Content					
L. Thickness, in	% Initial Moist. Cont.	Depth, ft	Fan Constant, FA	Airflow, cfm/bu	Ave	Bottom (Min.)	Top (Max.)	% DML Max	Drying Time, hrs	Failure or Success
30	21.0	25.0	3.3513	¼	18.82	13.06	20.44	0.3260	645	F
25	21.0	20.8	4.8817	½	17.01	12.29	20.19	0.1996	645	F
25	21.0	20.8	10.9009	1	12.68	11.07	15.49	0.2499	645	S*
30	21.0	25.0	27.4999	1½	14.40	9.71	18.31	0.1001	168	F
20	21.0	16.7	10.9916	1½	13.28	12.01	15.46	0.1652	450	S
21	18.0	17.5	3.3943	½	15.04	12.56	17.18	0.1040	645	F
14	18.0	11.7	1.4672	½	15.40	13.06	17.28	0.1002	645	F
22	18.0	18.3	5.8629	3/4	13.55	12.04	15.58	0.0927	645	F
22	18.0	18.3	5.8629	3/4	13.47	11.97	15.49	0.0930	651	S*

Table A.3. Simulation Results for Topeka Station

Year : 1972
Period: Oct. 5-Oct. 31
JDAY : 278

Grain Temp: 54
% Damage : 25
% Fine Mat: 12

Input					Output					Observation
					% Moisture Content					
L. Thickness, in	% Initial Moist. Cont.	Depth, ft	Fan Constant, FA	Airflow, cfm/bu	Ave	Bottom (Min.)	Top (Max.)	% DML Max	Drying Time, hrs	Failure or Success
30	21.0	25.0	3.3513	¼	19.34	14.85	20.62	0.2525	645	F
25	21.0	20.8	4.8877	½	17.89	14.33	20.49	0.1638	645	F
25	21.0	20.8	10.9009	1	14.04	12.59	16.55	0.2283	645	F
20	21.0	16.7	6.7415	1	13.98	13.23	15.45	0.2426	942	S*
20	21.0	16.7	10.9916	1½	13.54	12.43	15.50	0.1738	525	S
21	18.0	17.5	3.3943	½	15.85	14.15	17.52	0.0860	645	F
14	18.0	11.7	1.4672	½	16.20	14.66	17.59	0.0820	645	F
22	18.0	18.3	5.8629	3/4	13.93	13.22	15.22	0.0903	822	S*
25	18.0	20.8	10.9009	1	13.59	12.26	15.50	0.0691	438	S

Table A.4. Simulation Results for Dodge City Station

Year : 1963
Period: Oct. 20-Nov. 15
JDAY : 293

Grain Temp: 63
% Damage : 25
% Fine Mat: 12

Input					Output					Observation
					% Moisture Content					
L. Thickness, in	% Initial Moist. Cont.	Depth, ft	Fan Constant, FA	Airflow, cfm/bu	Ave	Bottom (Min.)	Top (Max.)	% DML Max	Drying Time, hrs	Failure or Success
22	21	18.3	8.2329	1	13.27	11.29	16.23	0.1971	645	F
20	21	16.7	6.7415	1	13.07	11.70	15.47	0.1991	747	S*
20	21	16.7	10.9916	1½	12.65	10.46	15.49	0.1659	461	S
22	18	17.5	3.3943	½	14.68	12.10	16.78	0.0757	645	F
22	18	17.5	3.3943	½	13.54	11.95	15.84	0.0882	1005	F
22	18	18.3	5.8629	3/4	13.22	11.61	15.37	0.0730	645	S*

Table A.5. Simulation Results for Dodge City Station

Year : 1971
Period: Oct. 20-Nov. 15
JDAY : 293

Grain Temp: 51
% Damage : 25
% Fine Mat: 12

Input					Output					Observation
					% Moisture Content					
L. Thickness, in	% Initial Moist. Cont.	Depth, ft	Fan Constant, FA	Airflow, cfm/bu	Ave	Bottom (Min.)	Top (Max.)	% DML Max	Drying Time, hrs	Failure or Success
22	21	18.3	8.2329	1	14.31	11.69	17.66	0.1423	645	F
20	21	16.7	6.7415	1	13.80	13.13	15.12	0.1608	1005	S*
20	21	16.7	10.9916	1½	12.84	10.54	15.49	0.1171	567	S
21	18	17.5	3.3943	½	15.57	12.68	17.61	0.0531	645	F
22	18	18.3	5.8629	3/4	14.10	11.93	16.45	0.0530	645	F
22	18	18.3	5.8629	3/4	13.62	12.41	15.49	0.0598	771	S*

Table A.6. Simulation Results for Dodge City Station

Year : 1972
Period: Oct. 20-Nov. 15
JDAY : 293

Grain Temp: 50
% Damage : 25
% Fine Mat: 12

Input					Output					Observation
					% Moisture Content					
L. Thickness, in	% Initial Moist. Cont.	Depth, ft	Fan Constant, FA	Airflow, cfm/bu	Ave	Bottom (Min.)	Top (Max.)	% DML Max	Drying Time, hrs	Failure or Success
22	21	18.3	8.2329	1	15.54	13.24	18.13	0.1004	645	F
20	21	16.7	6.7415	1	15.08	13.92	17.02	0.1082	1005	F
20	21	16.7	10.9916	1½	13.66	12.52	15.47	0.0853	645	S*
21	18	17.5	3.3943	½	15.97	14.17	17.32	0.0382	645	F
22	18	18.3	5.8629	3/4	14.86	13.34	16.46	0.0376	645	F
22	18	18.3	5.8629	3/4	14.50	13.88	15.61	0.0417	1005	F
22	18	18.3	8.2329	1	13.84	12.54	15.48	0.0347	600	S*

Table A.7. Simulation Results for Wichita Station

Year : 1963
Period: Oct. 15-Nov. 10
JDAY : 288

Grain Temp: 69
% Damage : 25
% Fine Mat: 12

Input					Output					Observation
					% Moisture Content					
L. Thickness, in	% Initial Moist. Cont.	Depth, ft	Fan Constant, FA	Airflow, cfm/bu	Ave	Bottom (Min.)	Top (Max.)	% DML Max	Drying Time, hrs	Failure or Success
20	21	16.7	1.4621	¼	18.04	14.87	19.52	0.5787	1029	F
20	21	16.7	3.0777	½	16.18	14.17	18.75	0.5162	1029	F
22	21	18.3	8.2329	1	13.74	12.09	16.36	0.3718	645	F
20	21	16.7	6.7415	1	13.53	12.63	15.45	0.3827	807	S*
20	21	16.7	10.9916	1½	13.20	11.57	15.50	0.2757	462	S
22	18	18.3	1.7631	¼	15.89	14.22	17.04	0.1749	1029	F
22	18	18.3	3.7278	½	14.47	13.61	15.82	0.1623	1029	F
21	18	17.5	3.3943	½	15.23	13.26	16.96	0.1407	645	F
22	18	18.3	5.8629	3/4	13.74	12.47	15.49	0.1339	663	S*
25	16	20.8	2.2932	¼	14.70	13.94	15.46	0.0376	1029	F
25	16	20.8	4.8877	½	13.96	12.88	15.17	0.0309	567	S*

Table A.8. Simulation Results for Wichita Station

Year : 1968
Period: Oct. 15-Nov. 10
JDAY : 288

Grain Temp: 64
% Damage : 25
% Fine Mat: 12

Input					Output					Observation
					% Moisture Content					
L. Thickness, in	% Initial Moist. Cont.	Depth, ft	Fan Constant, FA	Airflow, cfm/bu	Ave	Bottom (Min.)	Top (Max.)	% DML Max	Drying Time, hrs	Failure or Success
20	21	16.7	1.4621	¼	18.52	14.49	20.07	0.2783	1029	F
20	21	16.7	3.0777	½	16.64	14.02	19.34	0.2568	1029	F
22	21	18.3	8.2329	1	14.42	13.03	16.83	0.1953	645	F
20	21	16.7	6.7415	1	13.71	13.05	15.05	0.2062	1029	S*
20	21	16.7	10.9916	1½	13.20	12.08	15.50	0.1552	465	S
22	18	18.3	1.7631	¼	16.13	14.20	17.34	0.0942	1029	F
21	18	18.3	3.7278	½	14.69	13.75	16.21	0.0886	1029	F
22	18	18.3	5.8629	3/4	14.02	31.10	15.50	0.0728	669	S*
27	16	22.5	2.6959	¼	14.51	13.69	15.25	0.0690	1029	F
25	16	20.8	4.8877	½	13.76	12.56	14.96	0.0578	668	S
27	16	22.5	5.7501	½	13.60	12.38	14.88	0.0585	663	S*

Table A.9. Simulation Results for Wichita Station

Year : 1972
Period: Oct. 15-Nov. 10
JDAY : 288

Grain Temp: 62
% Damage : 25
% Fine Mat: 12

Input					Output					Observation
					% Moisture Content					
L. Thickness, in	% Initial Moist. Cont.	Depth, ft	Fan Constant, FA	Airflow, cfm/bu	Ave	Bottom (Min.)	Top (Max.)	% DML Max	Drying Time, hrs	Failure or Success
20	21	16.7	1.4621	¼	19.30	16.39	20.17	0.2035	1029	F
20	21	16.7	3.0777	½	18.11	15.55	19.85	0.1908	1029	F
20	21	16.7	6.7415	1	15.44	14.26	17.21	0.1703	1029	F
20	21	16.7	10.9916	1½	13.88	12.90	15.43	0.1301	723	S*
22	18	18.3	1.7631	¼	16.84	15.75	17.37	0.0709	1029	F
22	18	18.3	3.7278	½	15.96	15.02	16.93	0.0683	1029	F
22	18	18.3	5.8629	3/4	14.95	14.35	15.90	0.0652	1029	F
20	18	18.3	8.2329	1	14.00	13.67	14.62	0.0571	1020	S*
22	16	18.3	5.8629	3/4	14.40	14.25	14.62	0.0262	1029	F
22	16	20.8	7.7296	3/4	13.95	13.58	14.49	0.0247	747	S*
25	16	20.8	10.9009	1	13.61	13.20	14.22	0.0197	573	S

Table A.10. Simulation Results for Concordia Station

Year : 1963
Period: Oct. 15-Nov. 10
JDAY : 288

Grain Temp: 63
% Damage : 25
% Fine Mat: 12

Input					Output					Observation
					% Moisture Content					
L. Thickness, in	% Initial Moist. Cont.	Depth, ft	Fan Constant, FA	Airflow, cfm/bu	Ave	Bottom (Min.)	Top (Max.)	% DML Max	Drying Time, hrs	Failure or Success
22	21	18.3	8.2329	1	13.69	11.77	16.51	0.3192	645	F
20	21	16.7	6.7415	1	13.32	12.10	15.47	0.3235	804	S*
20	21	16.7	10.9916	1½	13.20	11.61	15.49	0.2398	468	S
21	18	17.5	3.3943	½	15.16	12.84	17.01	0.1218	645	F
14	18	11.7	1.4672	½	15.54	13.37	17.14	0.1177	645	F
22	18	18.3	5.8629	3/4	13.76	12.20	15.68	0.1152	645	F
22	18	18.3	5.8629	3/4	13.57	12.08	15.49	0.1162	666	S*
23	16	19.2	1.9455	¼	14.80	14.12	15.56	0.0310	1029	F
23	16	19.2	4.1234	½	14.00	12.85	15.16	0.0253	576	S
25	16	20.8	4.8877	½	13.90	12.69	15.12	0.0257	576	S*

Table A.11. Simulation Results for Concordia Station

Year : 1968
Period: Oct. 15-Nov. 10
JDAY : 288

Grain Temp: 60
% Damage : 25
% Fine Mat: 12

Input					Output						Observation
					% Moisture Content						
L. Thickness, in	% Initial Moist. Cont.	Depth, ft	Fan Constant, FA	Airflow, cfm/bu	Ave	Bottom (Min.)	Top (Max.)	% DML Max	Drying Time, hrs		Failure or Success
22	21	18.3	8.2329	1	14.62	13.23	16.90	0.1612	645		F
20	21	16.7	6.7415	1	13.85	13.20	15.31	0.1712	1029		S*
20	21	16.7	10.9916	1½	13.10	11.34	15.48	0.1310	465		S
21	18	17.5	3.3943	½	15.43	13.88	17.04	0.0631	645		F
14	18	11.7	1.4672	½	15.76	14.34	17.15	0.0603	645		F
22	18	18.3	5.8629	3/4	14.25	13.15	15.69	0.0595	645		F
22	18	18.3	5.8629	3/4	13.72	13.37	14.52	0.0644	1029		S*
25	16	20.8	2.2932	¼	14.39	13.28	15.36	0.0593	1029		F
25	16	20.8	4.8877	½	13.75	12.44	15.06	0.0501	645		S
27	16	22.5	5.7501	½	13.59	12.25	14.99	0.0507	645		S*

Table A.12. Simulation Results for Concordia Station

Year : 1972
Period: Oct. 15-Nov. 10
JDAY : 288

Grain Temp: 55
% Damage : 25
% Fine Mat: 12

Input					Output					Observation
					% Moisture Content					
L. Thickness, in	% Initial Moist. Cont.	Depth, ft	Fan Constant, FA	Airflow, cfm/bu	Ave	Bottom (Min.)	Top (Max.)	% DML Max	Drying Time, hrs	Failure or Success
22	21	18.3	8.2329	1	16.60	14.34	18.91	0.1381	645	F
20	21	16.7	10.9916	1½	14.72	13.39	16.50	0.1136	645	F
18	21	15.0	12.3857	2	13.96	12.84	15.47	0.0947	597	S*
18	21	15.0	16.5461	2½	13.88	12.91	15.15	0.0773	447	S
22	18	18.3	5.8629	3/4	15.86	14.67	17.02	0.0508	645	F
21	18	17.5	7.4628	1	14.96	14.72	15.39	0.0541	1029	F
20	18	16.7	10.9916	1½	13.66	13.10	14.45	0.0385	642	S*
20	18	16.7	15.8278	2	13.70	12.66	14.81	0.0247	321	S
22	16	18.3	8.2329	1	14.00	13.71	14.79	0.0194	621	S*
20	16	16.7	10.9916	1½	13.65	13.23	14.16	0.0143	531	S

Table A.13. Simulation Results for Goodland Station

Year : 1963
Period: Oct. 20-Nov. 15
JDAY : 293

Grain Temp: 62
% Damage : 25
% Fine Mat: 12

Input					Output					Observation
					% Moisture Content					
L. Thickness, in	% Initial Moist. Cont.	Depth, ft	Fan Constant, FA	Airflow, cfm/bu	Ave	Bottom (Min.)	Top (Max.)	% DML Max	Drying Time, hrs	Failure or Success
22	21	18.3	8.2329	1	13.65	11.15	16.74	0.1134	645	F
20	21	16.7	6.7415	1	13.47	12.24	15.48	0.1160	819	S*
20	21	16.7	10.9916	1½	13.00	11.14	15.50	0.0977	483	S
21	18	17.5	3.3943	½	14.82	11.96	16.87	0.0435	645	F
22	18	18.3	5.8629	3/4	13.42	11.52	15.58	0.0416	645	F
22	18	18.3	5.8629	3/4	13.25	11.44	15.49	0.0421	666	S*

Table A.14. Simulation Results for Goodland Station

Year : 1966
Period: Oct. 20-Nov. 15
JDAY : 293

Grain Temp: 50
% Damage : 25
% Fine Mat: 12

Input					Output					Observation
					% Moisture Content					
L. Thickness, in	% Initial Moist. Cont.	Depth, ft	Fan Constant, FA	Airflow, cfm/bu	Ave	Bottom (Min.)	Top (Max.)	% DML Max	Drying Time, hrs	Failure or Success
22	21	18.3	8.2329	1	14.53	12.15	17.46	0.0750	645	F
20	21	16.7	6.7415	1	13.53	12.49	15.47	0.0850	918	S*
20	21	16.7	10.9916	1½	13.29	11.79	15.50	0.0637	537	S
21	18	17.5	3.3943	½	15.36	13.17	17.25	0.0289	645	F
22	18	18.3	5.8629	3/4	14.07	12.49	16.00	0.0274	645	F
22	18	18.3	5.8629	3/4	13.52	12.05	15.48	0.0295	726	S*

Table A.15. Simulation Results for Goodland Station

Year : 1969
Period: Oct. 20-Nov. 15
JDAY : 293

Grain Temp: 45
% Damage : 25
% Fine Mat: 12

Input					Output					Observation
					% Moisture Content					
L. Thickness, in	% Initial Moist. Cont.	Depth, ft	Fan Constant, FA	Airflow, cfm/bu	Ave	Bottom (Min.)	Top (Max.)	% DML Max	Drying Time, hrs	Failure or Success
22	21	18.3	8.2329	1	15.71	12.37	18.54	0.0859	645	F
20	21	16.7	10.9916	1½	13.62	11.82	15.96	0.0769	645	F
18	21	15.0	8.6506	1½	14.24	12.53	15.94	0.0299	645	F
18	21	15.0	8.6506	1½	13.47	12.14	15.49	0.0792	777	S*
21	18	17.5	3.3943	½	16.16	13.48	17.50	0.0321	645	F
22	18	18.3	5.8629	3/4	15.02	12.71	16.81	0.0320	645	F
21	18	17.5	7.4628	1	14.07	12.36	15.81	0.0302	645	F
20	18	16.7	6.7415	1	14.24	12.53	15.94	0.0299	645	F
20	18	16.7	6.7415	1	13.82	12.38	15.46	0.0312	702	S*

APPENDIX B

SORGMDRY Input and Output Sample

B.1. Input

```
// EXEC FCRTGG,P=SORGMORY
//STEPLIB DD DSN=DSKN7.LCADLIB,DISP=SH9
//GO.FT03F001 DD DDNAME=SYSINI
//SYSINI DD *
215 3  0631.32   288 3 60580.0   288 6 59670.0   288 9 68610.0   63W-03 928
28812 79500.0   28815 82430.0   28818 80420.0   28821 75500.0
289 0 66750.0   289 3 60900.0   289 6 59930.0   289 9 61870.0
28912 69730.0   28915 71680.0   28918 69780.0   28921 67840.0
290 0 65900.0   290 3 64870.0   290 6 61900.0   290 9 65840.0
29012 69700.0   29015 74620.0   29018 70730.0   29021 67730.0
291 0 64730.0   291 3 61780.0   291 6 63670.0   291 9 66680.0
29112 76600.0   29115 83460.0   29118 74590.0   29121 68700.0
292 0 67730.0   292 3 63810.0   292 6 62840.0   292 9 68700.0
29212 77600.0   29215 78600.0   29218 74660.0   29221 72660.0
293 0 68760.0   293 3 64870.0   293 6 63870.0   293 9 62930.0
29312 64970.0   29315 67900.0   29318 66900.0   29321 66930.0
294 0 66900.0   294 3 66840.0   294 6 65840.0   294 9 67910.0
29412 72790.0   29415 76710.0   29418 72760.0   29421 67840.0
295 0 66900.0   295 3 63970.0   295 6 62930.0   295 9 66900.0
29512 76740.0   29515 75690.0   29518 74740.0   29521 67870.0
296 0 65870.0   296 3 64840.0   296 6 62840.0   296 9 67730.0
29612 76660.0   29615 78620.0   29618 74640.0   29621 65760.0
297 0 66810.0   297 3 63900.0   297 6 62930.0   297 9 65930.0
29712 71760.0   29715 73710.0   29718 70760.0   29721 63900.0
298 0 64900.0   298 3 62930.0   298 6 59960.0   298 9 63970.0
29812 70810.0   29815 76690.0   29818 70840.0   29821 67930.0
299 0 63970.0   299 3 61900.0   299 6 60930.0   299 9 65900.0
29912 76660.0   29915 79560.0   29918 72680.0   29921 66810.0
300 0 63870.0   300 3 60930.0   300 6 60930.0   300 9 57770.0
30012 50720.0   30015 56830.0   30018 54740.0   30021 50860.0
301 0 51710.0   301 3 47830.0   301 6 42890.0   301 9 51710.0
30112 62480.0   30115 62440.0   30118 51560.0   30121 43820.0
302 0 39850.0   302 3 39790.0   302 6 40700.0   302 9 46530.0
30212 55350.0   30215 59280.0   30218 56350.0   30221 54320.0
303 0 52330.0   303 3 50520.0   303 6 49580.0   303 9 57510.0
30312 68540.0   30315 74530.0   30318 69660.0   30321 67700.0
304 0 65750.0   304 3 60870.0   304 6 54560.0   304 9 53640.0
30412 57550.0   30415 58510.0   30418 53540.0   30421 50460.0
305 0 45530.0   305 3 36720.0   305 6 32820.0   305 9 43600.0
30512 55340.0   30515 58340.0   30518 50520.0   30521 44620.0
306 0 42670.0   306 3 37790.0   306 6 35780.0   306 9 43730.0
30612 58510.0   30615 62360.0   30618 55410.0   30621 51480.0
307 0 50410.0   307 3 51350.0   307 6 52350.0   307 9 54410.0
30712 59510.0   30715 56800.0   30718 57830.0   30721 52930.0
308 0 49960.0   308 3 51890.0   308 6 51930.0   308 9 52960.0
30812 56860.0   30815 62700.0   30818 55830.0   30821 46880.0
309 0 43930.0   309 3 40960.0   309 6 39930.0   309 9 48830.0
30912 63520.0   30915 70360.0   30918 59600.0   30921 56640.0
310 0 49960.0   310 3 43790.0   310 6 40820.0   310 9 50660.0
31012 64450.0   31015 68330.0   31018 60440.0   31021 53570.0
311 0 49610.0   311 3 50610.0   311 6 42650.0   311 9 56530.0
31112 70350.0   31115 74340.0   31118 67420.0   31121 62480.0
312 0 60490.0   312 3 57530.0   312 6 56570.0   312 9 58600.0
31212 67960.0   31215 69550.0   31218 64670.0   31221 57830.0
313 0 55930.0   313 3 50930.0   313 6 49930.0   313 9 52960.0
31312 67450.0   31315 70410.0   31318 62560.0   31321 51800.0
314 0 47960.0   314 3 47830.0   314 6 44930.0   314 9 52770.0
31412 66780.0   31415 70340.0   31418 56590.0   31421 47760.0
/*
//GO.FT13F001  DD SYSOUT=A,DCB=(RECFM=UA,BLKSIZE=133)
```

```
//GO.SYSIN DD *
SORGMORY FANMANAGEMENT USING USCA TEST 1-A FOR EVALUATION OF FANMANAGEMENT     1
WICHITA, KANSAS            3    3    3    0    1   20    0    6    0    3
  288    3     21.0      69.0      16.7      25.0      12.0
    1
HIGH SPEED AERATION 10.9916   0.0       0.0               0.50
/*
```

B.2. Output

LIST OF WEATHER DATA CARD DECK

WEATHER STATION IDENTIFICATION IS : W-03 9

```
215 3  063 1.32  288 3 6058 0.0   288 6 5967 0.0   288 9 6861 0.0
28812 7950 0.0   28815 8243 0.0   28818 8042 0.0   28821 7550 0.0
289 0 6675 0.0   289 3 6090 0.0   289 6 5993 0.0   289 9 6187 0.0
28912 6973 0.0   28915 7168 0.0   28918 6978 0.0   28921 6784 0.0
290 0 6590 0.0   290 3 6487 0.0   290 6 6190 0.0   290 9 6584 0.0
29012 6970 0.0   29015 7462 0.0   29018 7073 0.0   29021 6773 0.0
291 0 6473 0.0   291 3 6178 0.0   291 6 6367 0.0   291 9 6668 0.0
29112 7660 0.0   29115 8346 0.0   29116 7459 0.0   29121 6870 0.0
292 0 6773 0.0   292 3 6381 0.0   292 6 6284 0.0   292 9 6870 0.0
29212 7760 0.0   29215 7860 0.0   29218 7466 0.0   29221 7266 0.0
293 0 6876 0.0   293 3 6487 0.0   293 6 6387 0.0   293 9 6293 0.0
29312 6497 0.0   29315 6790 0.0   29318 6690 0.0   29321 6693 0.0
294 0 6690 0.0   294 3 6684 0.0   294 6 6584 0.0   294 9 6781 0.0
29412 7279 0.0   29415 7671 0.0   29418 7276 0.0   29421 6784 0.0
295 0 6690 0.0   295 3 6397 0.0   295 6 6293 0.0   295 9 6690 0.0
29512 7674 0.0   29515 7969 0.0   29518 7474 0.0   29521 6787 0.0
296 0 6587 0.0   296 3 6484 0.0   296 6 6284 0.0   296 9 6773 0.0
29612 7666 0.0   29615 7862 0.0   29618 7464 0.0   29621 6976 0.0
297 0 6681 0.0   297 3 6390 0.0   297 6 6293 0.0   297 9 6593 0.0
29712 7176 0.0   29715 7371 0.0   29718 7076 0.0   29721 6390 0.0
298 0 6490 0.0   298 3 6293 0.0   298 6 5996 0.0   298 9 6397 0.0
29812 7081 0.0   29815 7669 0.0   29818 7084 0.0   29821 6793 0.0
299 0 6397 0.0   299 3 6190 0.0   299 6 6093 0.0   299 9 6590 0.0
29912 7666 0.0   29915 7956 0.0   29918 7266 0.0   29921 6681 0.0
300 0 6387 0.0   300 3 6093 0.0   300 6 6093 0.0   300 9 5777 0.0
30012 6072 0.0   30015 5683 0.0   30018 5474 0.0   30021 5086 0.0
301 0 5171 0.0   301 3 4783 0.0   301 6 4289 0.0   301 9 5171 0.0
30112 6248 0.0   30115 6244 0.0   30118 5156 0.0   30121 4382 0.0
302 0 3985 0.0   302 3 3979 0.0   302 6 4070 0.0   302 9 4653 0.0
30212 5535 0.0   30215 5928 0.0   30218 5635 0.0   30221 5432 0.0
303 0 5238 0.0   303 3 5052 0.0   303 6 4958 0.0   303 9 5751 0.0
30312 6854 0.0   30315 7453 0.0   30318 6966 0.0   30321 6770 0.0
304 0 6575 0.0   304 3 6087 0.0   304 6 5496 0.0   304 9 5364 0.0
30412 5755 0.0   30415 5851 0.0   30418 5354 0.0   30421 5046 0.0
305 0 4553 0.0   305 3 3672 0.0   305 6 3282 0.0   305 9 4360 0.0
30512 5534 0.0   30515 5834 0.0   30518 5052 0.0   30521 4462 0.0
306 0 4267 0.0   306 3 3779 0.0   306 6 3578 0.0   306 9 4373 0.0
30612 5851 0.0   30615 6236 0.0   30618 5541 0.0   30621 5148 0.0
307 0 5041 0.0   307 3 5135 0.0   307 6 5235 0.0   307 9 5441 0.0
30712 5951 0.0   30715 5680 0.0   30718 5783 0.0   30721 5293 0.0
308 0 4996 0.0   308 3 5189 0.0   308 6 5193 0.0   308 9 5296 0.0
30812 5686 0.0   30815 6270 0.0   30818 5583 0.0   30821 4688 0.0
309 0 4393 0.0   309 3 4096 0.0   309 6 3993 0.0   309 9 4883 0.0
30912 6352 0.0   30915 7036 0.0   30918 5960 0.0   30921 5664 0.0
310 0 4956 0.0   310 3 4379 0.0   310 6 4082 0.0   310 9 5066 0.0
31012 6445 0.0   31015 6833 0.0   31018 6044 0.0   31021 5357 0.0
311 0 4961 0.0   311 3 5061 0.0   311 6 4865 0.0   311 9 5653 0.0
31112 7035 0.0   31115 7434 0.0   31118 6742 0.0   31121 6248 0.0
312 0 6049 0.0   312 3 5753 0.0   312 6 5657 0.0   312 9 5860 0.0
31212 6756 0.0   31215 6955 0.0   31218 6467 0.0   31221 5783 0.0
313 0 5593 0.0   313 3 5093 0.0   313 6 4993 0.0   313 9 5296 0.0
31312 6745 0.0   31315 7041 0.0   31318 6256 0.0   31321 5180 0.0
314 0 4786 0.0   314 3 4783 0.0   314 6 4493 0.0   314 9 5277 0.0
31412 6638 0.0   31415 7034 0.0   31418 5659 0.0   31421 4776 0.0
```

LISTING OF WEATHER DATA WITH THE TIME POINTER

60 58 14.027 6915	59 67 14.027 6918	68 61 14.027 6921	79 50 14.027 6924	82 43 14.027 6927	80 42 14.027 6930
75 50 14.027 6933	66 75 14.027 6936	60 90 14.027 6939	59 93 14.027 6942	61 87 14.027 6945	69 73 14.027 6948
71 68 14.027 6951	69 78 14.027 6954	67 84 14.027 6557	65 90 14.027 6960	64 87 14.027 6963	61 90 14.027 6966
65 84 14.027 6969	69 70 14.027 6972	74 62 14.027 6975	70 73 14.027 6978	67 73 14.027 6981	64 73 14.027 6984
61 78 14.027 6987	63 67 14.027 6990	66 68 14.027 6993	76 60 14.027 6996	83 46 14.027 6999	74 59 14.027 7002
68 70 14.027 7005	67 73 14.027 7008	63 81 14.027 7011	62 84 14.027 7014	68 70 14.027 7017	77 60 14.027 7020
78 60 14.027 7023	74 66 14.027 7026	72 66 14.027 7029	68 76 14.027 7032	64 87 14.027 7035	63 87 14.027 7038
62 93 14.027 7041	64 97 14.027 7044	67 90 14.027 7047	66 90 14.027 7050	66 93 14.027 7053	66 90 14.027 7056
66 84 14.027 7059	65 84 14.027 7062	67 81 14.027 7065	72 79 14.027 7068	76 71 14.027 7071	72 76 14.027 7074
67 84 14.027 7077	66 90 14.027 7080	63 97 14.027 7083	62 93 14.027 7086	66 90 14.027 7089	76 74 14.027 7092
79 69 14.027 7095	74 74 14.027 7098	67 87 14.027 7101	65 87 14.027 7104	64 84 14.027 7107	62 84 14.027 7110
67 73 14.027 7113	76 66 14.027 7116	78 62 14.027 7119	74 64 14.027 7122	69 76 14.027 7125	66 81 14.027 7128
63 90 14.027 7131	62 93 14.027 7134	65 93 14.027 7137	71 76 14.027 7140	73 71 14.027 7143	70 76 14.027 7146
63 90 14.027 7149	64 90 14.027 7152	62 93 14.027 7155	59 96 14.027 7158	63 97 14.027 7161	70 81 14.027 7164
76 69 14.027 7167	70 84 14.027 7170	67 93 14.027 7173	63 97 14.027 7176	61 90 14.027 7179	60 93 14.027 7182
65 90 14.027 7185	76 66 14.027 7188	79 56 14.027 7191	72 68 14.027 7194	66 81 14.027 7197	63 87 14.027 7200
60 93 14.027 7203	60 93 14.027 7206	57 77 14.027 7209	60 72 14.027 7212	56 83 14.027 7215	54 74 14.027 7218
50 86 14.027 7221	51 71 14.027 7224	47 83 14.027 7227	42 89 14.027 7230	51 71 14.027 7233	62 48 14.027 7236
62 44 14.027 7239	51 56 14.027 7242	43 82 14.027 7245	39 85 14.027 7248	39 79 14.027 7251	40 70 14.027 7254
46 53 14.027 7257	55 35 14.027 7260	59 28 14.027 7263	56 35 14.027 7266	54 32 14.027 7269	52 38 14.027 7272
50 52 14.027 7275	49 58 14.027 7278	57 51 14.027 7281	68 54 14.027 7284	74 53 14.027 7287	69 66 14.027 7290
67 70 14.027 7293	65 75 14.027 7296	60 87 14.027 7299	54 96 14.027 7302	53 64 14.027 7305	57 55 14.027 7308
58 51 14.027 7311	53 54 14.027 7314	50 46 14.027 7317	45 53 14.027 7320	36 72 14.027 7323	32 82 14.027 7326
43 60 14.027 7329	55 34 14.027 7332	58 34 14.027 7335	50 52 14.027 7338	44 62 14.027 7341	42 67 14.027 7344
37 79 14.027 7347	35 78 14.027 7350	43 73 14.027 7353	58 51 14.027 7356	62 36 14.027 7359	55 41 14.027 7362
51 48 14.027 7365	50 41 14.027 7368	51 35 14.027 7371	52 35 14.027 7374	54 41 14.027 7377	59 51 14.027 7380
56 80 14.027 7383	57 83 14.027 7386	52 93 14.027 7389	49 96 14.027 7392	51 89 14.027 7395	51 93 14.027 7398
52 96 14.027 7401	56 86 14.027 7404	62 70 14.027 7407	55 83 14.027 7410	46 88 14.027 7413	43 93 14.027 7416
40 96 14.027 7419	39 93 14.027 7422	48 83 14.027 7425	63 52 14.027 7428	70 36 14.027 7431	59 60 14.027 7434
56 64 14.027 7437	49 56 14.027 7440	43 79 14.027 7443	40 82 14.027 7446	50 66 14.027 7449	64 45 14.027 7452
68 33 14.027 7455	60 44 14.027 7458	53 57 14.027 7461	49 61 14.027 7464	50 61 14.027 7467	48 65 14.027 7470
56 53 14.027 7473	70 35 14.027 7476	74 34 14.027 7479	67 42 14.027 7482	62 48 14.027 7485	60 49 14.027 7488
57 53 14.027 7491	56 57 14.027 7494	58 60 14.027 7497	67 56 14.027 7500	69 55 14.027 7503	64 67 14.027 7506
57 83 14.027 7509	55 93 14.027 7512	50 93 14.027 7515	49 93 14.027 7518	52 96 14.027 7521	67 45 14.027 7524
70 41 14.027 7527	62 56 14.027 7530	51 80 14.027 7533	47 86 14.027 7536	47 83 14.027 7539	44 93 14.027 7542
52 77 14.027 7545	66 38 14.027 7548	70 34 14.027 7551	56 59 14.027 7554	47 76 14.027 7557	

WEATHER DATA AS CALCULATED BY WEATHER SUBROUTINE AND COMUNICATED TO THE TIME SUBROUTINE

60.0	0.58	14.027	288	3
82.0	0.43	14.027	288	15
60.0	0.90	14.027	289	3
71.0	0.68	14.027	289	15
64.0	0.87	14.027	290	3
74.0	0.62	14.027	290	15
61.0	0.78	14.027	291	3
83.0	0.46	14.027	291	15
63.0	0.81	14.027	292	3
78.0	0.60	14.027	292	15
64.0	0.87	14.027	293	3
67.0	0.90	14.027	293	15
66.0	0.84	14.027	294	3
76.0	0.71	14.027	294	15
63.0	0.97	14.027	295	3
79.0	0.69	14.027	295	15
64.0	0.84	14.027	296	3
78.0	0.62	14.027	296	15
63.0	0.90	14.027	297	3
73.0	0.71	14.027	297	15
62.0	0.93	14.027	298	3
76.0	0.69	14.027	298	15
61.0	0.90	14.027	299	3
79.0	0.56	14.027	299	15
60.0	0.93	14.027	300	3
56.0	0.83	14.027	300	15
47.0	0.83	14.027	301	3
62.0	0.44	14.027	301	15
39.0	0.79	14.027	302	3
59.0	0.28	14.027	302	15
50.0	0.52	14.027	303	3
74.0	0.53	14.027	303	15
60.0	0.87	14.027	304	3
58.0	0.51	14.027	304	15
36.0	0.72	14.027	305	3
58.0	0.34	14.027	305	15
37.0	0.79	14.027	306	3
62.0	0.36	14.027	306	15
51.0	0.35	14.027	307	3
56.0	0.80	14.027	307	15
51.0	0.89	14.027	308	3
62.0	0.70	14.027	308	15
40.0	0.96	14.027	309	3
70.0	0.36	14.027	309	15
43.0	0.79	14.027	310	3
68.0	0.33	14.027	310	15
50.0	0.61	14.027	311	3
74.0	0.34	14.027	311	15
57.0	0.53	14.027	312	3
69.0	0.55	14.027	312	15
50.0	0.93	14.027	313	3
70.0	0.41	14.027	313	15
47.0	0.83	14.027	314	3
70.0	0.34	14.027	314	15

59.0	0.67	14.027	288	6
80.0	0.42	14.027	288	18
59.0	0.93	14.027	289	6
69.0	0.78	14.027	289	18
61.0	0.90	14.027	290	6
70.0	0.73	14.027	290	18
63.0	0.67	14.027	291	6
74.0	0.59	14.027	291	18
62.0	0.84	14.027	292	6
74.0	0.66	14.027	292	18
63.0	0.87	14.027	293	6
66.0	0.90	14.027	293	18
65.0	0.84	14.027	294	6
72.0	0.76	14.027	294	18
62.0	0.93	14.027	295	6
74.0	0.74	14.027	295	18
62.0	0.84	14.027	296	6
74.0	0.64	14.027	296	18
62.0	0.93	14.027	297	6
70.0	0.76	14.027	297	18
59.0	0.96	14.027	298	6
70.0	0.84	14.027	298	18
60.0	0.93	14.027	299	6
72.0	0.68	14.027	299	18
60.0	0.93	14.027	300	6
54.0	0.74	14.027	300	18
42.0	0.89	14.027	301	6
51.0	0.56	14.027	301	18
40.0	0.70	14.027	302	6
56.0	0.35	14.027	302	18
49.0	0.58	14.027	303	6
69.0	0.66	14.027	303	18
54.0	0.96	14.027	304	6
53.0	0.54	14.027	304	18
32.0	0.82	14.027	305	6
50.0	0.52	14.027	305	18
35.0	0.78	14.027	306	6
55.0	0.41	14.027	306	18
52.0	0.35	14.027	307	6
57.0	0.83	14.027	307	18
51.0	0.93	14.027	308	6
55.0	0.83	14.027	308	18
39.0	0.93	14.027	309	6
59.0	0.60	14.027	309	18
40.0	0.82	14.027	310	6
60.0	0.44	14.027	310	18
48.0	0.65	14.027	311	6
67.0	0.42	14.027	311	18
56.0	0.57	14.027	312	6
64.0	0.67	14.027	312	18
49.0	0.93	14.027	313	6
62.0	0.56	14.027	313	18
44.0	0.93	14.027	314	6
56.0	0.59	14.027	314	18

68.0	0.61	14.027	288	9
75.0	0.50	14.027	288	21
61.0	0.87	14.027	289	9
67.0	0.84	14.027	289	21
65.0	0.84	14.027	290	9
67.0	0.73	14.027	290	21
66.0	0.68	14.027	291	9
68.0	0.70	14.027	291	21
68.0	0.70	14.027	292	9
72.0	0.66	14.027	292	21
62.0	0.93	14.027	293	9
66.0	0.93	14.027	293	21
67.0	0.81	14.027	294	9
67.0	0.84	14.027	294	21
66.0	0.90	14.027	295	9
67.0	0.87	14.027	295	21
67.0	0.73	14.027	296	9
69.0	0.76	14.027	296	21
65.0	0.93	14.027	297	9
63.0	0.90	14.027	297	21
63.0	0.97	14.027	298	9
67.0	0.93	14.027	298	21
65.0	0.90	14.027	299	9
66.0	0.81	14.027	299	21
57.0	0.77	14.027	300	9
50.0	0.86	14.027	300	21
51.0	0.71	14.027	301	9
43.0	0.82	14.027	301	21
46.0	0.53	14.027	302	9
54.0	0.32	14.027	302	21
57.0	0.51	14.027	303	9
67.0	0.70	14.027	303	21
53.0	0.64	14.027	304	9
50.0	0.46	14.027	304	21
43.0	0.60	14.027	305	9
44.0	0.62	14.027	305	21
43.0	0.73	14.027	306	9
51.0	0.48	14.027	306	21
54.0	0.41	14.027	307	9
52.0	0.93	14.027	307	21
52.0	0.96	14.027	308	9
46.0	0.88	14.027	308	21
48.0	0.83	14.027	309	9
56.0	0.64	14.027	309	21
50.0	0.66	14.027	310	9
53.0	0.57	14.027	310	21
56.0	0.53	14.027	311	9
62.0	0.48	14.027	311	21
58.0	0.60	14.027	312	9
57.0	0.83	14.027	312	21
52.0	0.96	14.027	313	9
51.0	0.80	14.027	313	21
52.0	0.77	14.027	314	9
47.0	0.76	14.027	314	21

79.0	0.50	14.027	288	12
66.0	0.75	14.027	289	0
69.0	0.73	14.027	289	12
65.0	0.90	14.027	290	0
69.0	0.70	14.027	290	12
64.0	0.73	14.027	291	0
76.0	0.60	14.027	291	12
67.0	0.73	14.027	292	0
77.0	0.60	14.027	292	12
68.0	0.76	14.027	293	0
64.0	0.97	14.027	293	12
66.0	0.90	14.027	294	0
72.0	0.79	14.027	294	12
66.0	0.90	14.027	295	0
76.0	0.74	14.027	295	12
65.0	0.87	14.027	296	0
76.0	0.66	14.027	296	12
66.0	0.81	14.027	297	0
71.0	0.76	14.027	297	12
64.0	0.90	14.027	298	0
70.0	0.81	14.027	298	12
63.0	0.97	14.027	299	0
76.0	0.66	14.027	299	12
63.0	0.87	14.027	300	0
60.0	0.72	14.027	300	12
51.0	0.71	14.027	301	0
62.0	0.48	14.027	301	12
39.0	0.85	14.027	302	0
55.0	0.35	14.027	302	12
52.0	0.38	14.027	303	0
68.0	0.54	14.027	303	12
65.0	0.75	14.027	304	0
57.0	0.55	14.027	304	12
45.0	0.53	14.027	305	0
55.0	0.34	14.027	305	12
42.0	0.67	14.027	306	0
58.0	0.51	14.027	306	12
50.0	0.41	14.027	307	0
59.0	0.51	14.027	307	12
49.0	0.96	14.027	308	0
56.0	0.86	14.027	308	12
43.0	0.93	14.027	309	0
63.0	0.52	14.027	309	12
49.0	0.56	14.027	310	0
64.0	0.45	14.027	310	12
49.0	0.61	14.027	311	0
70.0	0.35	14.027	311	12
60.0	0.49	14.027	312	0
67.0	0.56	14.027	312	12
55.0	0.93	14.027	313	0
67.0	0.45	14.027	313	12
47.0	0.86	14.027	314	0
66.0	0.38	14.027	314	12

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*****************************************************************************************************
                         ****                         ****
SIMULATION OF NATURAL-AIR GRAIN CONDITIONING  **  KANSAS STATE UNIVERSITY  **  DEPARTMENT OF AGRICULTURAL ENGINEERING
                         ****                         ****
*****************************************************************************************************

TITLE: SORGMDRY FANMANAGEMENT USING USDA TEST 1-N FOR EVALUATION OF FANMANAGEMENT    1       INVESTIGATOR: N.ILLANES

*****************************************************************************************************

BIN LOCATION: WICHITA, KANSAS       ****  WEATHER IDENTIFICATION: W-03 9    ****  TYPE OF GRAIN:    GRAIN SORGHUM

-----------------------------------------------------------------------------------------------------

        INITIAL GRAIN CONDITIONS AT EACH FILL                               BIN MANAGEMENT
*****************************************************************************************************
                          #1     #2     #3
MOISTURE CONTENT  =     0.21    0.0    0.0  WET BASIS              DATE BIN WAS FILLED    FILL #1   288,   3
GRAIN TEMPERATURE =     69.0    0.0    0.0  DEGREES F.                  (DAY,HOUR)             #2     0,   0
FINE MATERIAL     =     0.12    0.0    0.0  THRUS OF 12/64"                                    #3     0,   0
PERCENT DAMAGE    =     25.0    0.0    0.0  STAIN TEST %           WHEN WEATHER DATA STARTS          288,   3
DEPTH OF GRAIN    =     16.7    0.0    0.0  FEET                   HOW LONG CAN MODEL RUN              26 DAYS
*****************************************************************************************************

      MATHEMATICAL MODEL EMPIRICAL GRAIN CONSTANTS                 MATHEMATICAL MODEL ATTRIBUTES
-----------------------------------------------------------------------------------------------------
    CHUNG-PFOST EQUILIBRIUM MOISTURE EQUATION                  TIME TEST STARTS:     288, 3  (DAY,HOUR)
     A= 3933.1299    B= 19.6440    C=153.1280                  TIME INCREMENT:          3 HR

     D. K. SHARMA   SPECIFIC HEAT EQUATION                                         FILL      #1      #2      #3
     CA= 0.327            CB= 0.790                            NUMBER OF MODELED LAYERS:       10
                                                               THICKNESS OF EACH LAYER :       1.7
    DENSITY EQUATION        DRYING CONSTANT
    BO= 50.21    B1=-23.66     DC=  0.005
*****************************************************************************************************

                                        FAN MANAGEMENT
-----------------------------------------------------------------------------------------------------
                        TYPE OF FAN MANAGEMENT USED:
                          CONTINOUS OPERATION OF FAN AT HIGH SPEED

                                            FAN
                                           SPEED          FILL
                                                  #1       #2       #3
                        AIRFLOW RATE IN BIN       LOW     0.0
                          (CFM/SQ.FT.)           HIGH    20.20

                        POWER TO RUN FAN @ CFM    LOW    0.0
                          (KILOWATTS/HOUR)       HIGH    0.0522

                        STATIC PRESSURE           LOW    0.0
                        (INCHES WATER)           HIGH   10.9916

                     FAN TYPE                     COEFFICIENTS                        FAN EFFICIENCY

       LOW       (NO LOW SPEED FAN)      0.0        0.0       0.0                      0.0
       HIGH      HIGH SPEED AERATION    10.9916     0.0       0.0                      0.50
```

DRYING BED HEIGHT ABOVE BIN FLOOR (INCHES)
GRAIN MOISTURES (WB) AT EACH SENSING LOCATION

TIME	1-11-21	2-12-22	3-13-23	4-14-24	5-15-25	6-16-26	7-17-27	8-18-28	9-19-29	10-20-30
6918	9.968	29.907	49.851	69.798	89.750	109.705	129.664	149.626	169.591	189.558
	0.2082	0.2084	0.2085	0.2086	0.2087	0.2088	0.2089	0.2090	0.2091	0.2091
	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030
6921	9.943	29.835	49.738	69.648	89.566	109.489	129.417	149.351	169.288	189.230
	0.2068	0.2072	0.2074	0.2076	0.2078	0.2080	0.2081	0.2082	0.2083	0.2084
	0.0056	0.0055	0.0054	0.0054	0.0054	0.0055	0.0055	0.0055	0.0055	0.0056
6924	9.927	29.790	49.668	69.558	89.457	109.363	129.276	149.194	169.117	189.044
	0.2059	0.2064	0.2068	0.2071	0.2073	0.2075	0.2077	0.2078	0.2079	0.2081
	0.0079	0.0077	0.0076	0.0076	0.0076	0.0076	0.0077	0.0077	0.0078	0.0079
6927	9.906	29.735	49.592	69.469	89.360	109.261	129.170	149.086	169.006	188.930
	0.2048	0.2057	0.2064	0.2068	0.2072	0.2074	0.2076	0.2078	0.2079	0.2080
	0.0111	0.0104	0.0101	0.0098	0.0098	0.0097	0.0098	0.0098	0.0099	0.0100
6930	9.861	29.617	49.428	69.277	89.151	109.043	128.947	148.861	168.781	188.706
	0.2022	0.2041	0.2054	0.2062	0.2068	0.2072	0.2075	0.2078	0.2079	0.2080
	0.0162	0.0144	0.0133	0.0127	0.0123	0.0121	0.0121	0.0121	0.0121	0.0122
6933	9.801	29.456	49.199	69.000	88.843	108.715	128.607	148.514	168.431	188.356
	0.1988	0.2018	0.2038	0.2052	0.2061	0.2068	0.2073	0.2076	0.2079	0.2081
	0.0222	0.0192	0.0173	0.0161	0.0154	0.0149	0.0147	0.0145	0.0145	0.0145
6936	9.745	29.300	48.969	68.717	88.521	108.366	128.239	148.134	168.045	187.966
	0.1956	0.1994	0.2021	0.2039	0.2053	0.2062	0.2069	0.2074	0.2078	0.2080
	0.0276	0.0239	0.0215	0.0199	0.0188	0.0181	0.0176	0.0173	0.0171	0.0170
6939	9.702	29.180	48.788	68.488	88.255	108.072	127.925	147.806	167.707	187.623
	0.1931	0.1975	0.2005	0.2027	0.2044	0.2056	0.2064	0.2071	0.2076	0.2079
	0.0318	0.0279	0.0254	0.0236	0.0223	0.0214	0.0207	0.0203	0.0200	0.0198
6942	9.674	29.099	48.658	68.314	88.043	107.828	127.655	147.514	167.397	187.299
	0.1915	0.1960	0.1992	0.2016	0.2034	0.2047	0.2058	0.2066	0.2072	0.2076
	0.0345	0.0310	0.0285	0.0268	0.0255	0.0246	0.0239	0.0234	0.0230	0.0227
6945	9.658	29.050	48.575	68.198	87.896	107.652	127.452	147.288	167.150	187.034
	0.1905	0.1950	0.1983	0.2007	0.2025	0.2040	0.2051	0.2059	0.2066	0.2072
	0.0364	0.0332	0.0310	0.0295	0.0283	0.0275	0.0268	0.0263	0.0259	0.0257
6948	9.645	29.013	48.514	68.114	87.788	107.521	127.300	147.114	166.957	186.823
	0.1898	0.1943	0.1976	0.2000	0.2019	0.2033	0.2045	0.2054	0.2061	0.2067
	0.0380	0.0351	0.0332	0.0318	0.0308	0.0300	0.0294	0.0290	0.0287	0.0284
6951	9.636	28.986	48.473	68.059	87.722	107.443	127.210	147.013	166.845	186.700
	0.1893	0.1939	0.1972	0.1997	0.2016	0.2030	0.2042	0.2051	0.2058	0.2064
	0.0397	0.0369	0.0351	0.0339	0.0330	0.0323	0.0318	0.0315	0.0312	0.0310
6954	9.615	28.931	48.393	67.962	87.612	107.323	127.082	146.878	166.703	186.552
	0.1880	0.1931	0.1966	0.1993	0.2013	0.2028	0.2040	0.2049	0.2056	0.2062
	0.0420	0.0392	0.0374	0.0361	0.0352	0.0346	0.0342	0.0338	0.0336	0.0335
6957	9.592	28.867	48.301	67.852	87.489	107.193	126.947	146.740	166.564	186.412
	0.1867	0.1921	0.1960	0.1989	0.2010	0.2026	0.2039	0.2049	0.2056	0.2062

	0.0445	0.0418	0.0399	0.0386	0.0377	0.0371	0.0366	0.0363	0.0361	0.0359
6960	9.570 0.1854 0.0469	28.805 0.1911 0.0444	48.208 0.1952 0.0426	67.735 0.1983 0.0413	87.356 0.2006 0.0404	107.047 0.2024 0.0397	126.793 0.2037 0.0392	146.581 0.2048 0.0389	166.402 0.2056 0.0387	186.248 0.2062 0.0385
6963	9.551 0.1843 0.0490	28.752 0.1901 0.0468	48.125 0.1944 0.0452	67.627 0.1977 0.0440	87.228 0.2001 0.0431	106.904 0.2020 0.0425	126.637 0.2034 0.0420	146.417 0.2046 0.0416	166.231 0.2054 0.0414	186.073 0.2061 0.0413
6966	9.533 0.1832 0.0509	28.700 0.1892 0.0490	48.042 0.1936 0.0476	67.516 0.1969 0.0466	87.092 0.1995 0.0458	106.747 0.2015 0.0452	126.463 0.2030 0.0448	146.227 0.2042 0.0444	166.029 0.2051 0.0442	185.860 0.2059 0.0441
6969	9.515 0.1821 0.0525	28.647 0.1882 0.0510	47.957 0.1927 0.0499	67.402 0.1961 0.0490	86.952 0.1988 0.0484	106.583 0.2008 0.0479	126.278 0.2024 0.0475	146.023 0.2037 0.0472	165.808 0.2047 0.0470	185.625 0.2055 0.0469
6972	9.505 0.1815 0.0539	28.616 0.1876 0.0527	47.906 0.1921 0.0518	67.332 0.1956 0.0512	86.864 0.1983 0.0507	106.479 0.2004 0.0503	126.158 0.2020 0.0500	145.890 0.2033 0.0498	165.662 0.2044 0.0497	185.467 0.2052 0.0496
6975	9.488 0.1805 0.0554	28.570 0.1868 0.0545	47.835 0.1915 0.0538	67.240 0.1950 0.0533	86.753 0.1978 0.0529	106.351 0.1999 0.0527	126.016 0.2016 0.0525	145.733 0.2030 0.0523	165.493 0.2040 0.0522	185.286 0.2049 0.0522
6978	9.468 0.1793 0.0572	28.514 0.1859 0.0565	47.752 0.1908 0.0559	67.136 0.1945 0.0555	86.634 0.1974 0.0552	106.219 0.1996 0.0550	125.874 0.2014 0.0549	145.583 0.2028 0.0548	165.335 0.2039 0.0547	185.122 0.2047 0.0547
6981	9.440 0.1776 0.0593	28.437 0.1847 0.0588	47.640 0.1900 0.0583	66.999 0.1939 0.0579	86.479 0.1970 0.0577	106.052 0.1954 0.0575	125.698 0.2012 0.0573	145.401 0.2026 0.0573	165.149 0.2038 0.0573	184.933 0.2047 0.0573
6984	9.411 0.1758 0.0611	28.356 0.1832 0.0610	47.514 0.1888 0.0607	66.838 0.1930 0.0605	86.288 0.1963 0.0603	105.838 0.1988 0.0601	125.466 0.2007 0.0600	145.154 0.2023 0.0599	164.851 0.2035 0.0599	184.666 0.2044 0.0600
6987	9.385 0.1742 0.0626	28.279 0.1818 0.0629	47.393 0.1875 0.0629	66.676 0.1919 0.0629	86.092 0.1953 0.0628	105.612 0.1980 0.0627	125.214 0.2001 0.0626	144.881 0.2017 0.0626	164.599 0.2030 0.0626	184.358 0.2040 0.0627
6990	9.364 0.1729 0.0638	28.216 0.1805 0.0644	47.290 0.1864 0.0648	66.537 0.1909 0.0650	85.920 0.1944 0.0650	105.411 0.1972 0.0651	124.987 0.1994 0.0651	144.630 0.2011 0.0652	164.328 0.2025 0.0653	184.068 0.2036 0.0653
6993	9.345 0.1717 0.0647	28.159 0.1794 0.0657	47.198 0.1854 0.0664	66.411 0.1900 0.0668	85.762 0.1936 0.0671	105.223 0.1964 0.0673	124.772 0.1986 0.0674	144.390 0.2004 0.0676	164.065 0.2019 0.0677	183.784 0.2030 0.0678
6996	9.329 0.1707 0.0656	28.115 0.1786 0.0669	47.127 0.1846 0.0678	66.317 0.1893 0.0684	85.648 0.1930 0.0689	105.050 0.1959 0.0692	124.621 0.1982 0.0695	144.223 0.2000 0.0697	163.882 0.2015 0.0699	183.587 0.2026 0.0702
6999	9.318 0.1701 0.0666	28.084 0.1781 0.0681	47.082 0.1843 0.0693	66.262 0.1891 0.0701	85.585 0.1928 0.0706	105.022 0.1958 0.0711	124.549 0.1981 0.0714	144.148 0.1999 0.0718	163.804 0.2014 0.0721	183.507 0.2026 0.0724
7002	9.289 0.1682	28.006 0.1769	46.970 0.1835	66.127 0.1885	85.435 0.1925	104.863 0.1956	124.384 0.1980	143.980 0.1999	163.635 0.2014	183.337 0.2026

	0.0681	0.0699	0.0711	0.0720	0.0727	0.0732	0.0736	0.0740	0.0743	0.0746
7005	9.242	27.879	46.786	65.904	85.186	104.596	124.107	143.697	163.350	183.052
	0.1653	0.1748	0.1821	0.1876	0.1919	0.1952	0.1978	0.1998	0.2014	0.2026
	0.0701	0.0721	0.0735	0.0745	0.0751	0.0756	0.0760	0.0764	0.0767	0.0770
7008	9.208	27.779	46.631	65.702	84.948	104.330	123.820	143.395	163.037	182.732
	0.1631	0.1730	0.1805	0.1864	0.1909	0.1945	0.1973	0.1994	0.2011	0.2025
	0.0714	0.0740	0.0758	0.0770	0.0778	0.0783	0.0787	0.0791	0.0794	0.0797
7011	9.186	27.713	46.521	65.554	84.764	104.116	123.581	143.136	162.761	182.444
	0.1617	0.1716	0.1793	0.1853	0.1900	0.1937	0.1966	0.1989	0.2007	0.2022
	0.0723	0.0754	0.0777	0.0792	0.0802	0.0809	0.0814	0.0818	0.0822	0.0825
7014	9.166	27.655	46.425	65.422	84.600	103.923	123.362	142.893	162.499	182.164
	0.1605	0.1704	0.1782	0.1843	0.1891	0.1929	0.1959	0.1983	0.2002	0.2017
	0.0731	0.0766	0.0792	0.0812	0.0825	0.0834	0.0840	0.0845	0.0850	0.0853
7017	9.153	27.614	46.356	65.324	84.474	103.771	123.186	142.656	162.282	181.929
	0.1596	0.1695	0.1773	0.1834	0.1883	0.1922	0.1953	0.1977	0.1957	0.2013
	0.0736	0.0775	0.0806	0.0828	0.0844	0.0856	0.0864	0.0871	0.0876	0.0880
7020	9.144	27.584	46.304	65.250	84.380	103.656	123.052	142.543	162.113	181.744
	0.1590	0.1688	0.1766	0.1828	0.1877	0.1916	0.1947	0.1972	0.1992	0.2008
	0.0742	0.0784	0.0818	0.0843	0.0862	0.0876	0.0886	0.0894	0.0901	0.0906
7023	9.134	27.557	46.262	65.196	84.315	103.584	122.972	142.457	162.020	181.646
	0.1584	0.1683	0.1762	0.1825	0.1874	0.1914	0.1945	0.1971	0.1991	0.2007
	0.0748	0.0793	0.0830	0.0858	0.0879	0.0895	0.0907	0.0916	0.0924	0.0931
7026	9.110	27.493	46.169	65.084	84.191	103.452	122.835	142.318	161.880	181.506
	0.1569	0.1673	0.1755	0.1820	0.1872	0.1912	0.1945	0.1970	0.1991	0.2007
	0.0757	0.0805	0.0845	0.0876	0.0899	0.0916	0.0929	0.0939	0.0948	0.0955
7029	9.080	27.407	46.040	64.922	84.005	103.249	122.621	142.097	161.655	181.279
	0.1549	0.1657	0.1743	0.1812	0.1866	0.1908	0.1942	0.1969	0.1990	0.2007
	0.0766	0.0819	0.0863	0.0896	0.0921	0.0940	0.0954	0.0965	0.0974	0.0982
7032	9.053	27.328	45.913	64.754	83.803	103.019	122.371	141.830	161.376	180.991
	0.1532	0.1641	0.1730	0.1800	0.1857	0.1901	0.1937	0.1965	0.1987	0.2005
	0.0774	0.0832	0.0880	0.0917	0.0945	0.0965	0.0981	0.0993	0.1002	0.1010
7035	9.031	27.263	45.808	64.611	83.627	102.815	122.143	141.583	161.113	180.716
	0.1518	0.1628	0.1718	0.1790	0.1848	0.1894	0.1931	0.1960	0.1983	0.2002
	0.0780	0.0842	0.0895	0.0937	0.0968	0.0991	0.1008	0.1021	0.1031	0.1040
7038	9.016	27.217	45.728	64.499	83.485	102.646	121.949	141.368	160.880	180.467
	0.1508	0.1617	0.1707	0.1780	0.1839	0.1886	0.1924	0.1954	0.1979	0.1998
	0.0784	0.0851	0.0908	0.0954	0.0989	0.1015	0.1034	0.1049	0.1060	0.1070
7041	9.007	27.185	45.669	64.412	83.370	102.504	121.783	141.179	160.670	180.239
	0.1501	0.1609	0.1699	0.1772	0.1831	0.1879	0.1917	0.1948	0.1973	0.1993
	0.0788	0.0858	0.0919	0.0969	0.1007	0.1036	0.1058	0.1075	0.1088	0.1099
7044	9.001	27.165	45.631	64.354	83.291	102.405	121.664	141.042	160.515	180.067
	0.1498	0.1604	0.1692	0.1765	0.1825	0.1873	0.1912	0.1943	0.1968	0.1989
	0.0791	0.0864	0.0928	0.0982	0.1024	0.1056	0.1080	0.1099	0.1114	0.1126
7047	9.002	27.165	45.625	64.339	83.267	102.371	121.620	140.987	160.451	179.993
	0.1498	0.1602	0.1690	0.1763	0.1822	0.1870	0.1909	0.1940	0.1966	0.1986

	0.0794	0.0869	0.0937	0.0994	0.1039	0.1074	0.1101	0.1122	0.1139	0.1152
7050	9.002	27.163	45.617	64.324	83.244	102.340	121.582	140.942	160.399	179.935
	0.1498	0.1601	0.1688	0.1760	0.1820	0.1868	0.1907	0.1938	0.1964	0.1984
	0.0757	0.0875	0.0946	0.1006	0.1054	0.1092	0.1121	0.1144	0.1163	0.1178
7053	8.996	27.144	45.584	64.278	83.185	102.270	121.502	140.854	160.303	179.832
	0.1494	0.1596	0.1684	0.1756	0.1816	0.1865	0.1904	0.1936	0.1962	0.1983
	0.0800	0.0881	0.0955	0.1019	0.1070	0.1111	0.1142	0.1167	0.1187	0.1203
7056	8.992	27.130	45.558	64.239	83.135	102.209	121.432	140.776	160.219	179.743
	0.1492	0.1593	0.1680	0.1753	0.1813	0.1862	0.1902	0.1934	0.1960	0.1981
	0.0804	0.0887	0.0965	0.1032	0.1086	0.1129	0.1163	0.1190	0.1211	0.1229
7059	8.987	27.112	45.524	64.188	83.068	102.128	121.338	140.672	160.105	179.621
	0.1488	0.1588	0.1674	0.1748	0.1808	0.1858	0.1898	0.1931	0.1958	0.1979
	0.0807	0.0894	0.0975	0.1045	0.1103	0.1149	0.1185	0.1213	0.1236	0.1255
7062	8.979	27.085	45.476	64.119	82.978	102.020	121.213	140.530	159.951	179.455
	0.1483	0.1581	0.1668	0.1741	0.1802	0.1853	0.1894	0.1927	0.1954	0.1976
	0.0810	0.0900	0.0984	0.1058	0.1119	0.1168	0.1207	0.1237	0.1262	0.1282
7065	8.969	27.056	45.425	64.045	82.883	101.904	121.079	140.380	159.785	179.276
	0.1477	0.1574	0.1661	0.1734	0.1796	0.1847	0.1889	0.1923	0.1950	0.1973
	0.0814	0.0906	0.0993	0.1070	0.1134	0.1187	0.1228	0.1260	0.1287	0.1308
7068	8.963	27.036	45.387	63.990	82.810	101.814	120.973	140.260	159.653	179.132
	0.1473	0.1569	0.1655	0.1729	0.1791	0.1842	0.1884	0.1919	0.1947	0.1970
	0.0816	0.0911	0.1002	0.1082	0.1149	0.1204	0.1248	0.1283	0.1311	0.1334
7071	8.962	27.030	45.375	63.971	82.784	101.782	120.935	140.217	159.606	179.081
	0.1472	0.1567	0.1653	0.1727	0.1789	0.1840	0.1883	0.1918	0.1946	0.1969
	0.0820	0.0916	0.1010	0.1093	0.1164	0.1222	0.1268	0.1305	0.1335	0.1359
7074	8.954	27.007	45.339	63.923	82.727	101.718	120.867	140.146	159.532	179.006
	0.1467	0.1562	0.1649	0.1724	0.1787	0.1839	0.1882	0.1917	0.1945	0.1969
	0.0823	0.0923	0.1019	0.1106	0.1180	0.1241	0.1289	0.1328	0.1355	0.1385
7077	8.935	26.953	45.254	63.813	82.596	101.572	120.708	139.978	159.358	178.828
	0.1454	0.1552	0.1640	0.1716	0.1781	0.1835	0.1879	0.1915	0.1944	0.1968
	0.0828	0.0930	0.1030	0.1121	0.1198	0.1261	0.1313	0.1353	0.1386	0.1413
7080	8.919	26.902	45.168	63.693	82.448	101.398	120.513	139.766	159.131	178.590
	0.1443	0.1540	0.1629	0.1707	0.1773	0.1828	0.1873	0.1910	0.1940	0.1965
	0.0832	0.0937	0.1041	0.1135	0.1216	0.1283	0.1337	0.1380	0.1414	0.1442
7083	8.912	26.878	45.122	63.623	82.353	101.280	120.374	139.609	158.959	178.404
	0.1439	0.1533	0.1621	0.1699	0.1766	0.1821	0.1867	0.1905	0.1936	0.1962
	0.0834	0.0942	0.1050	0.1148	0.1233	0.1304	0.1361	0.1406	0.1443	0.1472
7086	8.907	26.859	45.083	63.562	82.269	101.174	120.248	139.462	158.794	178.224
	0.1435	0.1528	0.1615	0.1692	0.1759	0.1815	0.1861	0.1900	0.1932	0.1957
	0.0837	0.0947	0.1058	0.1160	0.1249	0.1323	0.1383	0.1432	0.1470	0.1502
7089	8.902	26.842	45.047	63.504	82.188	101.069	120.119	139.311	158.622	178.032
	0.1432	0.1522	0.1608	0.1685	0.1751	0.1808	0.1855	0.1894	0.1926	0.1952
	0.0839	0.0951	0.1065	0.1170	0.1263	0.1341	0.1405	0.1456	0.1497	0.1530
7092	8.905	26.846	45.047	63.495	82.167	101.035	120.072	139.250	158.548	177.945
	0.1434	0.1522	0.1606	0.1682	0.1748	0.1804	0.1851	0.1850	0.1922	0.1948

	0.0841	0.0955	0,1071	0.1179	0.1275	0.1356	0.1423	0.1478	0.1521	0.1557
7095	8.910	26.860	45.066	63.516	82.188	101.055	120.090	139.267	158.562	177.956
	0.1438	0.1524	0.1607	0.1682	0.1747	0.1803	0.1850	0.1889	0.1921	0.1948
	0.0843	0.0958	0.1077	0.1188	0.1287	0.1372	0.1442	0.1499	0.1544	0.1582
7098	8.902	26.838	45.034	63.478	82.147	101.012	120.047	139.225	158.522	177.918
	0.1432	0.1520	0.1604	0.1680	0.1747	0.1803	0.1850	0.1890	0.1922	0.1949
	0.0846	0.0964	0.1085	0.1199	0,1301	0,1389	0,1462	0,1521	0.1569	0.1608
7101	8.881	26.776	44.938	63.354	82.002	100.851	119.874	139.044	158.337	177.730
	0.1418	0.1508	0.1594	0.1673	0.1741	0.1799	0.1848	0.1868	0.1921	0.1948
	0.0850	0.0971	0.1095	0.1213	0.1318	0.1409	0.1485	0.1546	0.1596	0.1637
7104	8.863	26.721	44.846	63.226	81.841	100.663	119.664	138.815	158.092	177.474
	0.1406	0.1495	0.1582	0.1662	0.1732	0.1792	0.1842	0.1883	0.1917	0.1945
	0.0854	0.0977	0,1105	0,1226	0.1336	0.1430	0.1509	0.1574	0.1625	0.1668
7107	8.853	26.689	44.784	63.132	81.714	100.505	119.476	138.601	157.855	177.217
	0.1399	0.1486	0.1572	0.1652	0.1722	0.1782	0.1833	0.1876	0.1911	0.1940
	0.0856	0.0981	0.1112	0.1238	0.1352	0.1450	0.1533	0.1601	0.1655	0.1699
7110	8.846	26.664	44.735	63.055	81.607	100.367	119.309	138.406	157.634	176.972
	0.1394	0.1479	0.1564	0.1642	0.1712	0.1773	0.1825	0.1868	0.1904	0.1933
	0,0857	0.0984	0.1118	0.1247	0.1365	0.1468	0.1554	0.1625	0.1683	0.1729
7113	8.839	26.639	44.688	62.982	81.506	100.239	119.153	138.223	157.425	176.738
	0.1389	0.1473	0.1556	0.1634	0.1704	0.1765	0.1817	0.1860	0.1896	0.1927
	0.0859	0.0987	0.1123	0.1255	0.1377	0.1483	0.1573	0.1647	0.1708	0.1757
7116	8.836	26.627	44.662	62.938	81.443	100.154	119.047	138.096	157.278	176.571
	0.1387	0.1469	0.1550	0.1628	0.1697	0.1758	0.1810	0.1854	0.1891	0.1921
	0.0860	0.0990	0.1127	0.1262	0.1386	0.1496	0.1589	0.1667	0.1730	0.1782
7119	8.837	26.630	44.662	62.936	81.436	100.142	115.029	138.073	157.248	176.535
	0.1388	0.1468	0.1550	0.1626	0.1696	0.1757	0.1809	0.1852	0.1889	0.1919
	0.0862	0.0992	0.1132	0.1269	0.1396	0.1508	0.1604	0.1685	0.1750	0.1804
7122	8.825	26.595	44.611	62.871	81.361	100.060	118.942	137.981	157.154	176.438
	0.1380	0.1462	0.1545	0.1623	0.1693	0.1755	0.1807	0.1851	0.1888	0.1919
	0.0864	0.0996	0.1138	0.1277	0.1407	0.1522	0.1621	0.1703	0.1771	0.1827
7125	8.802	26.529	44.507	62.736	81.200	99.878	118.744	137.771	156.934	176.212
	0.1364	0.1449	0.1533	0.1614	0.1686	0.1749	0.1803	0.1848	0.1886	0.1917
	0.0867	0.1001	0.1144	0.1287	0.1419	0.1537	0.1639	0.1724	0.1794	0.1852
7128	8.785	26.478	44.422	62.617	81.052	99.704	118.549	137.558	156.708	175.976
	0.1353	0.1437	0.1522	0.1604	0.1677	0.1742	0.1797	0.1844	0.1882	0.1914
	0.0869	0.1004	0.1151	0.1296	0.1432	0.1553	0.1658	0.1746	0.1818	0.1878
7131	8.775	26.444	44.358	62.523	80.926	99.550	118.368	137.355	156.485	175.735
	0.1346	0.1428	0.1512	0.1594	0.1668	0.1734	0.1790	0.1837	0.1877	0.1910
	0.0870	0.1007	0.1156	0.1304	0.1444	0.1569	0.1677	0.1768	0.1843	0.1905
7134	8.769	26.424	44.319	62.459	80.837	99.435	118.228	137.192	156.301	175.532
	0.1347	0.1422	0.1505	0.1585	0.1660	0.1726	0.1783	0.1831	0.1871	0.1905
	0.0871	0.1010	0.1160	0.1312	0.1455	0.1583	0.1695	0.1789	0.1867	0.1932
7137	8.776	26.433	44.314	62.435	80.792	99.366	118.136	137.077	156.165	175.377
	0.1347	0.1418	0.1499	0.1579	0.1653	0.1718	0.1776	0.1924	0.1865	0.1899

	0.0872	0.1012	0.1164	0.1318	0.1464	0.1596	0.1711	0.1809	0.1890	0.1957
7140	8.791	26.464	44.343	62.458	80.804	99.366	118.122	137.049	156.123	175.321
	0.1357	0.1419	0.1498	0.1576	0.1649	0.1714	0.1771	0.1820	0.1861	0.1896
	0.0873	0.1013	0.1167	0.1323	0.1472	0.1607	0.1726	0.1827	0.1911	0.1981
7143	8.793	26.466	44.343	62.451	80.788	99.340	118.085	137.002	156.065	175.254
	0.1358	0.1419	0.1496	0.1573	0.1646	0.1711	0.1768	0.1817	0.1858	0.1893
	0.0874	0.1015	0.1170	0.1328	0.1480	0.1618	0.1740	0.1844	0.1931	0.2003
7146	8.787	26.450	44.315	62.411	80.737	99.277	118.013	136.920	155.974	175.155
	0.1354	0.1415	0.1492	0.1570	0.1642	0.1708	0.1765	0.1814	0.1856	0.1891
	0.0876	0.1018	0.1174	0.1334	0.1489	0.1630	0.1755	0.1862	0.1952	0.2026
7149	8.776	26.417	44.261	62.337	80.644	99.168	117.889	136.784	155.828	175.000
	0.1347	0.1408	0.1486	0.1563	0.1637	0.1703	0.1761	0.1811	0.1853	0.1888
	0.0878	0.1020	0.1179	0.1341	0.1498	0.1642	0.1770	0.1880	0.1972	0.2049
7152	8.762	26.377	44.196	62.247	80.528	99.028	117.728	136.603	155.631	174.789
	0.1337	0.1400	0.1477	0.1555	0.1629	0.1696	0.1755	0.1806	0.1849	0.1885
	0.0879	0.1023	0.1183	0.1347	0.1507	0.1655	0.1786	0.1899	0.1994	0.2073
7155	8.766	26.381	44.188	62.221	80.482	98.960	117.638	136.494	155.504	174.645
	0.1340	0.1397	0.1472	0.1548	0.1622	0.1689	0.1749	0.1800	0.1844	0.1880
	0.0880	0.1024	0.1186	0.1353	0.1516	0.1666	0.1801	0.1917	0.2015	0.2097
7158	8.772	26.388	44.184	62.201	80.442	98.900	117.556	136.391	155.381	174.505
	0.1344	0.1394	0.1467	0.1542	0.1615	0.1682	0.1742	0.1794	0.1838	0.1875
	0.0881	0.1026	0.1189	0.1358	0.1523	0.1677	0.1815	0.1935	0.2036	0.2121
7161	8.780	26.399	44.181	62.179	80.400	98.835	117.468	136.281	155.249	174.352
	0.1349	0.1390	0.1462	0.1536	0.1608	0.1675	0.1735	0.1787	0.1832	0.1869
	0.0882	0.1027	0.1191	0.1362	0.1530	0.1687	0.1828	0.1951	0.2055	0.2143
7164	8.805	26.450	44.235	62.230	80.442	98.867	117.489	136.288	155.244	174.334
	0.1366	0.1392	0.1461	0.1534	0.1605	0.1672	0.1731	0.1783	0.1828	0.1865
	0.0883	0.1029	0.1194	0.1366	0.1536	0.1696	0.1839	0.1965	0.2072	0.2163
7167	8.809	26.464	44.255	62.252	80.464	98.885	117.502	136.296	155.246	174.330
	0.1369	0.1395	0.1463	0.1534	0.1605	0.1670	0.1730	0.1782	0.1826	0.1864
	0.0884	0.1030	0.1196	0.1370	0.1542	0.1704	0.1851	0.1979	0.2089	0.2182
7170	8.808	26.463	44.253	62.249	80.459	98.877	117.492	136.283	155.230	174.312
	0.1369	0.1395	0.1463	0.1534	0.1604	0.1670	0.1729	0.1781	0.1825	0.1863
	0.0886	0.1032	0.1199	0.1374	0.1549	0.1713	0.1863	0.1994	0.2107	0.2202
7173	8.797	26.433	44.209	62.194	80.393	98.803	117.411	136.198	155.142	174.222
	0.1361	0.1390	0.1458	0.1530	0.1601	0.1667	0.1727	0.1780	0.1825	0.1863
	0.0888	0.1034	0.1203	0.1380	0.1556	0.1724	0.1876	0.2010	0.2126	0.2224
7176	8.794	26.421	44.184	62.152	80.335	98.730	117.325	136.101	155.036	174.110
	0.1359	0.1386	0.1453	0.1525	0.1596	0.1663	0.1724	0.1777	0.1823	0.1862
	0.0889	0.1036	0.1206	0.1386	0.1565	0.1735	0.1891	0.2028	0.2146	0.2247
7179	8.798	26.421	44.167	62.114	80.273	98.644	117.216	135.970	154.887	173.945
	0.1362	0.1381	0.1447	0.1517	0.1588	0.1655	0.1717	0.1771	0.1817	0.1857
	0.0891	0.1038	0.1209	0.1391	0.1573	0.1746	0.1906	0.2046	0.2168	0.2271
7182	8.792	26.402	44.130	62.054	80.186	98.529	117.072	135.759	154.689	173.723
	0.1358	0.1376	0.1440	0.1509	0.1579	0.1646	0.1708	0.1762	0.1810	0.1850

	0.0892	0.1040	0.1212	0.1395	0.1580	0.1757	0.1919	0.2064	0.2185	0.2295
7185	8.796	26.406	44.124	62.032	80.144	98.464	116.983	135.685	154.551	173.561
	0.1360	0.1374	0.1435	0.1503	0.1572	0.1639	0.1700	0.1755	0.1803	0.1844
	0.0893	0.1041	0.1214	0.1399	0.1586	0.1765	0.1931	0.2079	0.2208	0.2317
7188	8.806	26.431	44.154	62.062	80.169	98.480	116.987	135.676	154.529	173.525
	0.1367	0.1377	0.1436	0.1502	0.1570	0.1635	0.1696	0.1751	0.1799	0.1839
	0.0894	0.1042	0.1216	0.1402	0.1591	0.1773	0.1941	0.2093	0.2224	0.2337
7191	8.810	26.442	44.172	62.083	80.190	98.498	117.000	135.683	154.529	173.517
	0.1370	0.1379	0.1438	0.1502	0.1569	0.1634	0.1695	0.1749	0.1796	0.1837
	0.0895	0.1043	0.1218	0.1405	0.1596	0.1780	0.1951	0.2106	0.2240	0.2356
7194	8.796	26.406	44.121	62.019	80.116	98.414	116.908	135.583	154.421	173.403
	0.1360	0.1374	0.1433	0.1499	0.1566	0.1631	0.1692	0.1747	0.1794	0.1835
	0.0897	0.1045	0.1221	0.1409	0.1602	0.1788	0.1962	0.2119	0.2257	0.2375
7197	8.773	26.343	44.028	61.902	79.977	98.258	116.737	135.401	154.230	173.204
	0.1344	0.1363	0.1424	0.1491	0.1560	0.1626	0.1688	0.1743	0.1792	0.1834
	0.0899	0.1048	0.1224	0.1414	0.1608	0.1797	0.1974	0.2134	0.2274	0.2395
7200	8.758	26.300	43.957	61.802	79.850	98.106	116.563	135.207	154.020	172.981
	0.1334	0.1353	0.1414	0.1482	0.1551	0.1619	0.1682	0.1738	0.1787	0.1830
	0.0901	0.1049	0.1227	0.1419	0.1615	0.1807	0.1987	0.2149	0.2293	0.2416
7203	8.751	26.278	43.916	61.738	79.760	97.989	116.420	135.040	153.831	172.773
	0.1330	0.1348	0.1407	0.1473	0.1542	0.1610	0.1674	0.1731	0.1781	0.1825
	0.0902	0.1051	0.1229	0.1423	0.1621	0.1816	0.1999	0.2165	0.2311	0.2438
7206	8.756	26.283	43.907	61.710	79.709	97.913	116.317	134.911	153.677	172.596
	0.1333	0.1344	0.1401	0.1466	0.1534	0.1602	0.1665	0.1723	0.1774	0.1818
	0.0903	0.1052	0.1231	0.1426	0.1626	0.1824	0.2010	0.2179	0.2329	0.2459
7209	8.766	26.301	43.918	61.708	79.691	97.875	116.257	134.828	153.572	172.469
	0.1340	0.1343	0.1398	0.1461	0.1528	0.1595	0.1658	0.1716	0.1767	0.1812
	0.0904	0.1053	0.1233	0.1429	0.1631	0.1830	0.2019	0.2192	0.2345	0.2478
7212	8.757	26.273	43.871	61.637	79.594	97.749	116.101	134.642	153.356	172.224
	0.1333	0.1336	0.1391	0.1453	0.1519	0.1586	0.1649	0.1707	0.1758	0.1803
	0.0904	0.1054	0.1234	0.1431	0.1634	0.1836	0.2027	0.2203	0.2359	0.2496
7215	8.753	26.262	43.849	61.602	79.539	97.673	116.003	134.520	153.210	172.053
	0.1331	0.1334	0.1387	0.1447	0.1513	0.1578	0.1641	0.1699	0.1751	0.1796
	0.0905	0.1054	0.1235	0.1433	0.1638	0.1841	0.2034	0.2212	0.2371	0.2511
7218	8.748	26.248	43.826	61.565	79.488	97.605	115.917	134.414	153.083	171.907
	0.1328	0.1331	0.1383	0.1443	0.1507	0.1573	0.1635	0.1693	0.1744	0.1790
	0.0906	0.1055	0.1237	0.1435	0.1640	0.1845	0.2041	0.2221	0.2382	0.2524
7221	8.741	26.227	43.789	61.510	79.412	97.507	115.795	134.269	152.914	171.715
	0.1323	0.1326	0.1377	0.1436	0.1500	0.1565	0.1628	0.1685	0.1737	0.1783
	0.0906	0.1056	0.1237	0.1436	0.1643	0.1849	0.2046	0.2228	0.2392	0.2536
7224	8.735	26.209	43.761	61.469	79.355	97.431	115.699	134.152	152.777	171.557
	0.1318	0.1323	0.1373	0.1431	0.1494	0.1559	0.1621	0.1679	0.1731	0.1777
	0.0907	0.1056	0.1238	0.1438	0.1645	0.1852	0.2051	0.2235	0.2401	0.2547
7227	8.731	26.196	43.737	61.429	79.296	97.352	115.598	134.028	152.630	171.387
	0.1315	0.1320	0.1368	0.1425	0.1488	0.1552	0.1614	0.1672	0.1724	0.1770

	0.0907	0.1056	0.1239	0.1439	0.1647	0.1855	0.2055	0.2241	0.2408	0.2556
7230	8.727	26.186	43.717	61.398	79.252	97.291	115.519	133.930	152.512	171.249
	0.1313	0.1317	0.1365	0.1421	0.1483	0.1546	0.1608	0.1665	0.1718	0.1764
	0.0907	0.1057	0.1240	0.1440	0.1649	0.1858	0.2059	0.2246	0.2415	0.2565
7233	8.727	26.182	43.704	61.372	79.210	97.232	115.441	133.832	152.393	171.110
	0.1313	0.1314	0.1361	0.1416	0.1477	0.1540	0.1602	0.1659	0.1711	0.1757
	0.0908	0.1057	0.1240	0.1440	0.1650	0.1860	0.2062	0.2250	0.2421	0.2572
7236	8.729	26.198	43.710	61.374	79.205	97.216	115.413	133.789	152.336	171.037
	0.1315	0.1315	0.1360	0.1415	0.1474	0.1536	0.1597	0.1654	0.1706	0.1752
	0.0908	0.1057	0.1240	0.1441	0.1651	0.1862	0.2065	0.2254	0.2426	0.2578
7239	8.728	26.183	43.703	61.365	79.190	97.193	115.380	133.746	152.280	170.969
	0.1313	0.1315	0.1359	0.1413	0.1472	0.1534	0.1594	0.1651	0.1703	0.1749
	0.0908	0.1058	0.1241	0.1442	0.1652	0.1863	0.2067	0.2257	0.2430	0.2583
7242	8.715	26.149	43.655	61.304	79.118	97.111	115.287	133.643	152.167	170.845
	0.1304	0.1309	0.1355	0.1409	0.1465	0.1530	0.1591	0.1647	0.1699	0.1745
	0.0909	0.1058	0.1241	0.1442	0.1653	0.1865	0.2069	0.2260	0.2434	0.2588
7245	8.697	26.099	43.578	61.204	78.998	96.973	115.133	133.473	151.984	170.650
	0.1292	0.1299	0.1347	0.1402	0.1462	0.1525	0.1586	0.1643	0.1695	0.1742
	0.0909	0.1059	0.1242	0.1443	0.1655	0.1867	0.2072	0.2264	0.2438	0.2593
7248	8.689	26.075	43.536	61.143	78.917	96.873	115.015	133.339	151.834	170.486
	0.1286	0.1293	0.1340	0.1395	0.1456	0.1518	0.1580	0.1638	0.1691	0.1738
	0.0910	0.1059	0.1243	0.1444	0.1656	0.1869	0.2075	0.2267	0.2443	0.2599
7251	8.687	26.067	43.515	61.106	78.861	96.796	114.917	133.219	151.694	170.328
	0.1285	0.1290	0.1335	0.1389	0.1449	0.1511	0.1573	0.1631	0.1685	0.1732
	0.0910	0.1059	0.1243	0.1445	0.1657	0.1870	0.2077	0.2271	0.2447	0.2604
7254	8.686	26.062	43.503	61.083	78.824	96.741	114.842	133.124	151.578	170.191
	0.1284	0.1288	0.1332	0.1385	0.1444	0.1505	0.1566	0.1625	0.1678	0.1726
	0.0910	0.1059	0.1243	0.1445	0.1658	0.1872	0.2079	0.2274	0.2451	0.2609
7257	8.684	26.057	43.493	61.064	78.793	96.696	114.780	133.044	151.479	170.072
	0.1283	0.1286	0.1330	0.1381	0.1439	0.1500	0.1561	0.1619	0.1672	0.1720
	0.0910	0.1059	0.1243	0.1446	0.1658	0.1873	0.2081	0.2276	0.2454	0.2613
7260	8.682	26.050	43.481	61.044	78.764	96.655	114.725	132.973	151.391	169.967
	0.1282	0.1285	0.1328	0.1378	0.1436	0.1496	0.1556	0.1613	0.1666	0.1714
	0.0910	0.1059	0.1244	0.1446	0.1659	0.1874	0.2082	0.2278	0.2456	0.2616
7263	8.676	26.033	43.454	61.008	78.717	96.597	114.654	132.888	151.292	169.853
	0.1278	0.1282	0.1324	0.1375	0.1432	0.1492	0.1552	0.1609	0.1662	0.1710
	0.0910	0.1060	0.1244	0.1446	0.1659	0.1874	0.2083	0.2279	0.2459	0.2619
7266	8.663	25.997	43.401	60.940	78.636	96.502	114.547	132.768	151.159	169.708
	0.1268	0.1275	0.1319	0.1370	0.1427	0.1487	0.1547	0.1605	0.1658	0.1706
	0.0910	0.1060	0.1244	0.1447	0.1660	0.1875	0.2084	0.2281	0.2461	0.2621
7269	8.647	25.954	43.336	60.857	78.536	96.389	114.422	132.632	151.013	169.552
	0.1257	0.1267	0.1312	0.1365	0.1423	0.1483	0.1544	0.1601	0.1655	0.1703
	0.0911	0.1060	0.1244	0.1447	0.1661	0.1876	0.2085	0.2282	0.2463	0.2624
7272	8.631	25.906	43.261	60.757	78.414	96.246	114.261	132.455	150.822	169.349
	0.1246	0.1257	0.1303	0.1356	0.1415	0.1477	0.1538	0.1597	0.1651	0.1699

	0.0911	0.1060	0.1245	0.1448	0.1661	0.1877	0.2087	0.2284	0.2465	0.2627
7275	8.617	25.867	43.199	60.671	78.306	96.118	114.112	132.290	150.641	169.154
	0.1236	0.1248	0.1295	0.1345	0.1408	0.1470	0.1532	0.1591	0.1646	0.1695
	0.0911	0.1061	0.1245	0.1448	0.1662	0.1878	0.2088	0.2286	0.2467	0.2630
7278	8.609	25.843	43.159	60.615	78.233	96.027	114.006	132.167	150.505	169.005
	0.1230	0.1243	0.1289	0.1343	0.1402	0.1464	0.1527	0.1586	0.1642	0.1692
	0.0911	0.1061	0.1245	0.1449	0.1663	0.1879	0.2090	0.2288	0.2470	0.2633
7281	8.604	25.827	43.131	60.574	78.177	95.956	113.919	132.065	150.388	168.876
	0.1227	0.1239	0.1285	0.1338	0.1397	0.1459	0.1522	0.1582	0.1637	0.1688
	0.0911	0.1061	0.1246	0.1449	0.1663	0.1880	0.2091	0.2291	0.2473	0.2636
7284	8.602	25.822	43.121	60.557	78.151	95.920	113.871	132.005	150.316	168.792
	0.1225	0.1238	0.1283	0.1335	0.1394	0.1455	0.1518	0.1578	0.1634	0.1685
	0.0912	0.1061	0.1246	0.1450	0.1664	0.1881	0.2093	0.2293	0.2476	0.2640
7287	8.606	25.836	43.145	60.589	78.190	95.962	113.916	132.052	150.363	168.840
	0.1228	0.1241	0.1286	0.1338	0.1395	0.1457	0.1518	0.1578	0.1634	0.1685
	0.0912	0.1061	0.1246	0.1450	0.1665	0.1882	0.2095	0.2295	0.2478	0.2643
7290	8.605	25.837	43.153	60.606	78.215	95.996	113.958	132.101	150.421	168.905
	0.1228	0.1243	0.1289	0.1341	0.1398	0.1459	0.1521	0.1581	0.1636	0.1687
	0.0912	0.1061	0.1247	0.1451	0.1666	0.1884	0.2096	0.2297	0.2482	0.2648
7293	8.596	25.814	43.123	60.573	78.182	95.966	113.932	132.081	150.408	168.900
	0.1221	0.1240	0.1287	0.1340	0.1399	0.1461	0.1523	0.1583	0.1639	0.1690
	0.0912	0.1062	0.1247	0.1451	0.1667	0.1886	0.2099	0.2301	0.2487	0.2653
7296	8.590	25.795	43.092	60.530	78.128	95.903	113.862	132.008	150.333	168.826
	0.1217	0.1236	0.1283	0.1336	0.1395	0.1458	0.1521	0.1582	0.1639	0.1691
	0.0913	0.1062	0.1248	0.1453	0.1669	0.1888	0.2103	0.2306	0.2492	0.2660
7299	8.586	25.784	43.071	60.496	78.080	95.839	113.785	131.918	150.234	168.721
	0.1214	0.1233	0.1279	0.1332	0.1390	0.1453	0.1517	0.1578	0.1636	0.1689
	0.0913	0.1063	0.1249	0.1454	0.1671	0.1891	0.2107	0.2311	0.2500	0.2669
7302	8.603	25.814	43.089	60.499	78.065	95.805	113.730	131.844	150.142	168.615
	0.1226	0.1230	0.1274	0.1326	0.1384	0.1446	0.1510	0.1572	0.1631	0.1685
	0.0913	0.1063	0.1249	0.1455	0.1672	0.1894	0.2111	0.2317	0.2507	0.2679
7305	8.629	25.858	43.118	60.510	78.055	95.771	113.671	131.758	150.032	168.481
	0.1245	0.1225	0.1268	0.1319	0.1376	0.1438	0.1501	0.1564	0.1623	0.1676
	0.0914	0.1063	0.1250	0.1456	0.1674	0.1896	0.2115	0.2323	0.2515	0.2689
7308	8.619	25.829	43.069	60.435	77.950	95.633	113.499	131.552	149.750	168.206
	0.1238	0.1218	0.1260	0.1309	0.1365	0.1427	0.1490	0.1553	0.1612	0.1668
	0.0914	0.1064	0.1250	0.1456	0.1675	0.1898	0.2118	0.2328	0.2522	0.2698
7311	8.614	25.814	43.041	60.391	77.885	95.544	113.382	131.406	149.614	167.999
	0.1234	0.1215	0.1255	0.1303	0.1358	0.1418	0.1480	0.1543	0.1603	0.1658
	0.0914	0.1064	0.1250	0.1457	0.1676	0.1900	0.2121	0.2332	0.2528	0.2705
7314	8.607	25.794	43.009	60.344	77.821	95.460	113.276	131.275	149.458	167.817
	0.1229	0.1211	0.1250	0.1297	0.1351	0.1411	0.1473	0.1535	0.1594	0.1650
	0.0914	0.1064	0.1251	0.1457	0.1677	0.1901	0.2123	0.2335	0.2532	0.2712
7317	8.596	25.764	42.962	60.280	77.738	95.357	113.151	131.127	149.286	167.620
	0.1221	0.1205	0.1244	0.1291	0.1345	0.1403	0.1465	0.1527	0.1587	0.1642

	0.0915	0.1064	0.1251	0.1458	0.1677	0.1902	0.2124	0.2338	0.2536	0.2717
7320	8.585	25.732	42.909	60.204	77.639	95.233	113.001	130.952	149.084	167.352
	0.1213	0.1198	0.1237	0.1283	0.1336	0.1395	0.1456	0.1518	0.1578	0.1634
	0.0915	0.1064	0.1251	0.1458	0.1678	0.1903	0.2126	0.2340	0.2540	0.2722
7323	8.576	25.707	42.867	60.143	77.557	95.129	112.874	130.759	148.906	167.189
	0.1207	0.1192	0.1230	0.1276	0.1329	0.1387	0.1448	0.1510	0.1570	0.1626
	0.0915	0.1064	0.1251	0.1458	0.1678	0.1904	0.2127	0.2342	0.2543	0.2726
7326	8.567	25.682	42.830	60.092	77.489	95.042	112.765	130.668	148.751	167.011
	0.1200	0.1188	0.1226	0.1270	0.1322	0.1380	0.1441	0.1502	0.1562	0.1618
	0.0915	0.1064	0.1251	0.1459	0.1679	0.1905	0.2128	0.2344	0.2545	0.2730
7329	8.577	25.699	42.838	60.090	77.472	95.008	112.711	130.592	148.653	166.889
	0.1208	0.1185	0.1223	0.1266	0.1317	0.1374	0.1434	0.1495	0.1555	0.1611
	0.0915	0.1065	0.1251	0.1459	0.1679	0.1905	0.2129	0.2345	0.2547	0.2732
7332	8.579	25.705	42.846	60.096	77.473	95.000	112.692	130.558	148.602	166.820
	0.1209	0.1186	0.1223	0.1265	0.1315	0.1370	0.1429	0.1490	0.1549	0.1605
	0.0915	0.1065	0.1252	0.1459	0.1679	0.1905	0.2130	0.2346	0.2549	0.2734
7335	8.577	25.699	42.838	60.084	77.455	94.974	112.655	130.509	148.539	166.741
	0.1208	0.1186	0.1222	0.1263	0.1312	0.1367	0.1426	0.1485	0.1544	0.1599
	0.0915	0.1065	0.1252	0.1459	0.1679	0.1906	0.2130	0.2347	0.2550	0.2736
7338	8.569	25.679	42.811	60.051	77.418	94.931	112.605	130.451	148.472	166.664
	0.1202	0.1183	0.1219	0.1261	0.1310	0.1365	0.1423	0.1482	0.1541	0.1596
	0.0915	0.1065	0.1252	0.1459	0.1679	0.1906	0.2131	0.2347	0.2551	0.2737
7341	8.559	25.652	42.773	60.005	77.365	94.872	112.541	130.381	148.396	166.581
	0.1195	0.1178	0.1216	0.1259	0.1308	0.1363	0.1421	0.1481	0.1539	0.1594
	0.0915	0.1065	0.1252	0.1459	0.1680	0.1906	0.2131	0.2348	0.2552	0.2739
7344	8.552	25.633	42.742	59.961	77.309	94.804	112.462	130.292	148.297	166.473
	0.1190	0.1174	0.1212	0.1255	0.1304	0.1359	0.1418	0.1477	0.1536	0.1591
	0.0915	0.1065	0.1252	0.1459	0.1680	0.1907	0.2132	0.2349	0.2553	0.2740
7347	8.549	25.624	42.726	59.936	77.272	94.754	112.398	130.215	148.207	166.371
	0.1188	0.1172	0.1209	0.1251	0.1300	0.1355	0.1413	0.1473	0.1532	0.1587
	0.0915	0.1065	0.1252	0.1459	0.1680	0.1907	0.2132	0.2350	0.2554	0.2742
7350	8.558	25.641	42.737	59.938	77.263	94.732	112.362	130.163	148.139	166.288
	0.1194	0.1171	0.1206	0.1247	0.1295	0.1350	0.1408	0.1468	0.1526	0.1582
	0.0915	0.1065	0.1252	0.1460	0.1680	0.1907	0.2133	0.2351	0.2556	0.2744
7353	8.567	25.659	42.753	59.947	77.262	94.719	112.335	130.119	148.079	166.210
	0.1201	0.1171	0.1204	0.1244	0.1292	0.1345	0.1403	0.1462	0.1521	0.1577
	0.0915	0.1065	0.1252	0.1460	0.1681	0.1908	0.2133	0.2352	0.2557	0.2746
7356	8.582	25.702	42.810	60.005	77.317	94.769	112.376	130.151	148.098	166.216
	0.1211	0.1181	0.1205	0.1244	0.1290	0.1343	0.1399	0.1458	0.1517	0.1572
	0.0916	0.1065	0.1252	0.1460	0.1681	0.1908	0.2134	0.2352	0.2558	0.2747
7359	8.586	25.716	42.835	60.037	77.356	94.811	112.419	130.192	148.136	166.249
	0.1214	0.1185	0.1208	0.1246	0.1292	0.1343	0.1399	0.1457	0.1515	0.1571
	0.0916	0.1065	0.1252	0.1460	0.1681	0.1908	0.2134	0.2353	0.2559	0.2749
7362	8.578	25.697	42.810	60.010	77.326	94.777	112.381	130.150	148.087	166.194
	0.1209	0.1182	0.1207	0.1245	0.1291	0.1342	0.1398	0.1455	0.1513	0.1568

	0.0916	0.1065	0.1252	0.1460	0.1681	0.1908	0.2135	0.2354	0.2560	0.2750
7365	8.563	25.657	42.753	59.939	77.244	94.686	112.282	130.042	147.972	166.070
	0.1198	0.1175	0.1201	0.1241	0.1287	0.1339	0.1395	0.1453	0.1510	0.1566
	0.0916	0.1065	0.1252	0.1460	0.1681	0.1909	0.2135	0.2354	C.2561	0.2751
7368	8.553	25.627	42.706	59.876	77.166	94.594	112.176	129.924	147.843	165.932
	0.1190	0.1169	0.1196	0.1236	0.1282	0.1335	0.1391	0.1449	0.1507	0.1563
	0.0916	0.1065	0.1253	0.1460	0.1682	0.1909	0.2136	0.2355	0.2562	0.2753
7371	8.543	25.599	42.660	59.811	77.082	94.491	112.054	129.783	147.685	165.758
	0.1183	0.1163	0.1189	0.1229	0.1275	0.1328	0.1384	0.1443	0.1501	0.1558
	0.0916	0.1065	0.1253	0.1460	0.1682	0.1910	0.2136	0.2356	0.2563	0.2755
7374	8.533	25.571	42.616	59.750	77.001	94.390	111.932	129.641	147.522	165.576
	0.1176	0.1157	0.1183	0.1222	0.1269	0.1321	0.1377	0.1436	0.1495	0.1552
	0.0916	0.1C65	0.1253	0.1461	0.1682	0.1910	0.2137	0.2357	0.2565	0.2757
7377	8.524	25.546	42.576	59.695	76.930	94.301	111.825	129.514	147.376	165.410
	0.1170	0.1152	0.1178	0.1217	0.1263	0.1314	0.1371	0.1429	0.1488	0.1546
	0.0916	0.1065	0.1253	0.1461	0.1682	0.1910	0.2138	0.2358	0.2566	0.2758
7380	8.518	25.528	42.549	59.658	76.882	94.240	111.751	129.426	147.272	165.291
	0.1165	0.1148	0.1174	0.1213	0.1259	0.1310	0.1366	0.1424	0.1483	0.1541
	0.0916	0.1066	0.1253	0.1461	0.1682	0.1911	0.2138	0.2359	0.2567	0.2760
7383	8.517	25.527	42.548	59.657	76.880	94.235	111.741	129.410	147.250	165.261
	0.1164	0.1149	0.1174	0.1213	0.1258	0.1309	0.1364	0.1422	0.1481	0.1536
	0.0916	0.1066	0.1253	0.1461	0.1683	0.1911	0.2139	0.2360	0.2568	0.2762
7386	8.541	25.589	42.627	59.741	76.968	94.326	111.834	129.503	147.342	165.351
	0.1182	0.1158	0.1177	0.1215	0.1259	0.1309	0.1364	0.1422	0.1480	0.1537
	0.0916	0.1066	0.1253	0.1461	0.1683	0.1911	0.2139	0.2360	0.2570	0.2763
7389	8.568	25.655	42.709	59.827	77.056	94.417	111.924	129.593	147.431	165.439
	0.1201	0.1168	0.1178	C.1216	0.1260	0.1310	0.1364	0.1422	0.1480	0.1537
	0.0917	0.1066	0.1253	0.1461	0.1683	0.1912	0.2140	0.2361	0.2571	0.2766
7392	8.597	25.722	42.781	59.895	77.120	94.474	111.975	129.636	147.467	165.468
	0.1222	0.1173	0.1177	0.1214	0.1258	0.1307	0.1362	0.1419	0.1478	0.1535
	0.0917	0.1066	0.1253	0.1461	0.1683	0.1912	0.2141	0.2363	0.2573	0.2768
7395	8.627	25.789	42.854	59.962	77.177	94.520	112.008	129.656	147.473	165.462
	0.1243	0.1179	0.1175	0.1211	0.1254	0.1303	0.1357	0.1415	0.1473	0.1531
	0.0917	0.1066	0.1253	0.1462	0.1684	0.1913	0.2142	0.2364	0.2575	0.2771
7398	8.648	25.848	42.929	60.036	77.244	94.578	112.054	129.688	147.490	165.464
	0.1258	0.1190	0.1176	0.1210	0.1251	0.1299	0.1353	0.1410	0.1468	0.1526
	0.0917	0.1066	0.1254	0.1462	0.1684	0.1913	0.2142	0.2365	0.2577	0.2774
7401	8.674	25.917	43.023	60.134	77.339	94.665	112.132	129.754	147.542	165.501
	0.1276	0.1203	0.1181	0.1209	0.1249	0.1296	0.1349	0.1405	0.1463	0.1521
	0.0917	0.1066	0.1254	0.1462	0.1684	0.1914	0.2143	0.2366	0.2579	0.2776
7404	8.703	25.997	43.133	60.255	77.458	94.781	112.240	129.853	147.630	165.577
	0.1297	0.1218	0.1188	0.1209	0.1248	0.1295	0.1346	0.1402	0.1459	0.1517
	0.0918	0.1066	0.1254	0.1462	0.1685	0.1914	0.2144	0.2368	0.2581	0.2779
7407	8.714	26.040	43.212	60.349	77.554	94.876	112.332	129.938	147.708	165.645
	0.1304	0.1233	0.1198	0.1210	0.1249	0.1294	0.1345	0.1400	0.1457	0.1513

	0.0918	0.1066	0.1254	0.1462	0.1685	0.1914	0.2144	0.2369	0.2582	0.2781
7410	8.716	26.045	43.232	60.385	77.596	94.918	112.373	129.976	147.741	165.671
	0.1305	0.1235	0.1206	0.1213	0.1249	0.1294	0.1344	0.1398	0.1455	0.1511
	0.0918	0.1067	0.1254	0.1462	0.1685	0.1915	0.2145	0.2370	0.2584	0.2784
7413	8.709	26.036	43.229	60.385	77.593	94.911	112.360	129.957	147.712	165.634
	0.1301	0.1237	0.1209	0.1212	0.1248	0.1292	0.1342	0.1355	0.1452	0.1508
	0.0919	0.1067	0.1254	0.1463	0.1685	0.1915	0.2146	0.2371	0.2586	0.2787
7416	8.701	26.016	43.199	60.342	77.537	94.841	112.274	129.853	147.590	165.494
	0.1295	0.1235	0.1204	0.1208	0.1243	0.1287	0.1336	0.1389	0.1445	0.1502
	0.0919	0.1067	0.1254	0.1463	0.1686	0.1916	0.2147	0.2372	0.2588	0.2789
7419	8.711	26.040	43.224	60.360	77.544	94.833	112.248	129.806	147.522	165.403
	0.1302	0.1237	0.1203	0.1205	0.1239	0.1281	0.1329	0.1382	0.1438	0.1495
	0.0920	0.1067	0.1254	0.1463	0.1686	0.1916	0.2147	0.2373	0.2589	0.2792
7422	8.725	26.074	43.266	60.399	77.574	94.850	112.249	129.788	147.483	165.340
	0.1312	0.1241	0.1203	0.1202	0.1235	0.1276	0.1323	0.1375	0.1430	0.1487
	0.0920	0.1067	0.1255	0.1463	0.1686	0.1917	0.2148	0.2374	0.2591	0.2794
7425	8.736	26.105	43.308	60.442	77.611	94.878	112.264	129.787	147.463	165.300
	0.1320	0.1247	0.1206	0.1200	0.1232	0.1272	0.1318	0.1369	0.1424	0.1480
	0.0920	0.1068	0.1255	0.1463	0.1686	0.1917	0.2148	0.2375	0.2592	0.2796
7428	8.748	26.151	43.394	60.552	77.728	94.993	112.374	129.850	147.554	165.377
	0.1328	0.1263	0.1218	0.1206	0.1232	0.1271	0.1316	0.1366	0.1419	0.1475
	0.0920	0.1068	0.1255	0.1463	0.1686	0.1917	0.2149	0.2375	0.2593	0.2797
7431	8.751	26.160	43.413	60.589	77.782	95.053	112.437	129.953	147.615	165.433
	0.1330	0.1266	0.1221	0.1215	0.1235	0.1272	0.1316	0.1365	0.1418	0.1472
	0.0920	0.1068	0.1255	0.1463	0.1686	0.1917	0.2149	0.2376	0.2593	0.2798
7434	8.739	26.131	43.378	60.554	77.748	95.021	112.406	129.921	147.581	165.395
	0.1321	0.1263	0.1221	0.1215	0.1235	0.1273	0.1316	0.1365	0.1417	0.1471
	0.0921	0.1068	0.1255	0.1463	0.1687	0.1917	0.2149	0.2376	0.2594	0.2800
7437	8.719	26.083	43.316	60.489	77.683	94.958	112.345	129.862	147.523	165.337
	0.1308	0.1256	0.1218	0.1215	0.1236	0.1274	0.1317	0.1365	0.1417	0.1471
	0.0922	0.1068	0.1255	0.1464	0.1687	0.1918	0.2150	0.2377	0.2595	0.2801
7440	8.707	26.050	43.269	60.432	77.619	94.887	112.268	129.780	147.435	165.244
	0.1299	0.1250	0.1214	0.1212	0.1234	0.1271	0.1315	0.1364	0.1416	0.1469
	0.0922	0.1069	0.1255	0.1464	0.1687	0.1918	0.2150	0.2378	0.2596	0.2802
7443	8.692	26.008	43.204	60.346	77.515	94.763	112.125	129.617	147.254	165.046
	0.1289	0.1241	0.1207	0.1205	0.1227	0.1265	0.1308	0.1357	0.1409	0.1463
	0.0923	0.1069	0.1256	0.1464	0.1687	0.1918	0.2151	0.2379	0.2597	0.2804
7446	8.686	25.989	43.175	60.308	77.464	94.700	112.046	129.521	147.140	164.913
	0.1285	0.1237	0.1203	0.1202	0.1223	0.1259	0.1303	0.1351	0.1403	0.1457
	0.0923	0.1069	0.1256	0.1464	0.1687	0.1919	0.2151	0.2379	0.2599	0.2806
7449	8.683	25.982	43.167	60.294	77.442	94.666	111.998	129.456	147.056	164.809
	0.1282	0.1237	0.1202	0.1199	0.1219	0.1255	0.1297	0.1345	0.1397	0.1450
	0.0923	0.1069	0.1256	0.1464	0.1688	0.1919	0.2152	0.2380	0.2600	0.2807
7452	8.685	25.990	43.187	60.327	77.476	94.696	112.021	129.468	147.055	164.793
	0.1284	0.1239	0.1209	0.1201	0.1218	0.1253	0.1294	0.1341	0.1392	0.1445

	0.0923	0.1069	0.1256	0.1464	0.1688	0.1919	0.2152	0.2380	0.2600	0.2809
7455	8.686	25.994	43.196	60.343	77.498	94.722	112.047	129.492	147.073	164.802
	0.1284	0.1241	0.1212	0.1203	0.1220	0.1254	0.1294	0.1339	0.1389	0.1442
	0.0924	0.1069	0.1256	0.1464	0.1688	0.1919	0.2152	0.2381	0.2601	0.2810
7458	8.671	25.958	43.149	60.292	77.445	94.667	111.989	129.430	147.005	164.727
	0.1274	0.1236	0.1209	0.1202	0.1219	0.1253	0.1292	0.1338	0.1387	0.1439
	0.0924	0.1070	0.1256	0.1464	0.1688	0.1919	0.2152	0.2381	0.2602	0.2811
7461	8.650	25.902	43.074	60.204	77.350	94.567	111.885	129.322	146.892	164.608
	0.1259	0.1226	0.1204	0.1199	0.1217	0.1251	0.1291	0.1336	0.1385	0.1437
	0.0924	0.1070	0.1256	0.1465	0.1688	0.1920	0.2153	0.2382	0.2602	0.2812
7464	8.635	25.861	43.013	60.128	77.263	94.469	111.778	129.205	146.767	164.475
	0.1249	0.1218	0.1198	0.1195	0.1214	0.1248	0.1288	0.1333	0.1382	0.1434
	0.0925	0.1070	0.1256	0.1465	0.1688	0.1920	0.2153	0.2382	0.2603	0.2813
7467	8.626	25.834	42.970	60.071	77.192	94.384	111.679	129.092	146.639	164.333
	0.1243	0.1212	0.1192	0.1190	0.1209	0.1243	0.1283	0.1328	0.1377	0.1429
	0.0925	0.1070	0.1257	0.1465	0.1688	0.1920	0.2153	0.2383	0.2604	0.2814
7470	8.622	25.822	42.949	60.042	77.154	94.336	111.617	129.016	146.548	164.226
	0.1239	0.1209	0.1190	0.1187	0.1205	0.1239	0.1278	0.1323	0.1372	0.1424
	0.0925	0.1070	0.1257	0.1465	0.1689	0.1920	0.2154	0.2383	0.2605	0.2815
7473	8.617	25.810	42.932	60.019	77.125	94.298	111.570	128.956	146.474	164.136
	0.1236	0.1207	0.1188	0.1185	0.1203	0.1235	0.1274	0.1318	0.1367	0.1419
	0.0925	0.1071	0.1257	0.1465	0.1689	0.1921	0.2154	0.2384	0.2606	0.2816
7476	8.616	25.807	42.928	60.015	77.119	94.289	111.554	128.931	146.439	164.088
	0.1235	0.1207	0.1188	0.1185	0.1202	0.1234	0.1271	0.1315	0.1363	0.1414
	0.0925	0.1071	0.1257	0.1465	0.1689	0.1921	0.2154	0.2384	0.2606	0.2817
7479	8.612	25.797	42.916	60.004	77.109	94.278	111.540	128.914	146.414	164.055
	0.1232	0.1206	0.1188	0.1185	0.1202	0.1233	0.1270	0.1313	0.1360	0.1411
	0.0926	0.1071	0.1257	0.1465	0.1689	0.1921	0.2155	0.2385	0.2607	0.2818
7482	8.597	25.760	42.870	59.956	77.062	94.233	111.496	128.869	146.368	164.006
	0.1222	0.1201	0.1186	0.1185	0.1203	0.1234	0.1270	0.1313	0.1360	0.1410
	0.0926	0.1071	0.1257	0.1465	0.1689	0.1921	0.2155	0.2385	0.2608	0.2819
7485	8.574	25.699	42.786	59.858	76.956	94.123	111.383	128.754	146.250	163.885
	0.1206	0.1190	0.1180	0.1182	0.1201	0.1232	0.1269	0.1312	0.1359	0.1409
	0.0926	0.1071	0.1257	0.1466	0.1689	0.1921	0.2155	0.2386	0.2608	0.2820
7488	8.556	25.650	42.712	59.765	76.847	94.001	111.250	128.611	146.098	163.725
	0.1193	0.1180	0.1172	0.1176	0.1196	0.1228	0.1266	0.1309	0.1356	0.1406
	0.0927	0.1071	0.1257	0.1466	0.1689	0.1922	0.2156	0.2386	0.2609	0.2822
7491	8.544	25.614	42.655	59.690	76.755	93.892	111.124	128.469	145.941	163.553
	0.1184	0.1172	0.1165	0.1169	0.1190	0.1222	0.1260	0.1303	0.1350	0.1401
	0.0927	0.1072	0.1258	0.1466	0.1690	0.1922	0.2156	0.2387	0.2610	0.2823
7494	8.534	25.586	42.611	59.630	76.680	93.801	111.016	128.343	145.757	163.391
	0.1177	0.1166	0.1159	0.1164	0.1184	0.1216	0.1254	0.1297	0.1344	0.1395
	0.0927	0.1072	0.1258	0.1466	0.1690	0.1922	0.2156	0.2387	0.2611	0.2824
7497	8.528	25.569	42.584	59.593	76.633	93.741	110.942	128.253	145.689	163.265
	0.1173	0.1162	0.1156	0.1160	0.1180	0.1212	0.1249	0.1291	0.1338	0.1389

	0.0927	0.1072	0.1258	0.1466	0.1690	0.1922	0.2157	0.2388	0.2612	0.2826
7500	8.527	25.565	42.577	59.583	76.619	93.721	110.914	128.214	145.637	163.199
	0.1172	0.1161	0.1155	0.1159	0.1178	0.1209	0.1245	0.1287	0.1333	0.1384
	0.0927	0.1072	0.1258	0.1466	0.1690	0.1923	0.2157	0.2388	0.2613	0.2827
7503	8.530	25.576	42.597	59.614	76.658	93.764	110.958	128.257	145.676	163.231
	C.1174	0.1164	0.1158	0.1164	0.1180	0.1210	0.1245	0.1286	0.1331	0.1381
	0.0927	0.1C72	0.1258	0.1466	0.1690	0.1923	0.2157	0.2389	0.2613	0.2828
7506	8.528	25.571	42.595	59.617	76.668	93.779	110.976	128.275	145.694	163.245
	0.1173	0.1165	0.1160	0.1166	0.1182	0.1211	0.1246	0.1286	0.1331	0.1380
	0.0927	0.1072	0.1258	0.1466	0.1690	0.1923	0.2158	0.2389	0.2614	0.2829
7509	8.522	25.556	42.577	59.599	76.651	93.764	110.962	128.261	145.678	163.227
	0.1168	0.1163	0.1159	0.1166	0.1183	0.1212	0.1246	0.1285	0.1330	0.1378
	0.0928	0.1072	0.1258	0.1467	0.1691	0.1923	0.2158	0.2390	0.2615	0.2830
7512	8.538	25.586	42.599	59.614	76.660	93.766	110.957	128.248	145.657	163.196
	0.1180	0.1160	0.1157	0.1164	0.1181	0.1209	0.1243	0.1283	0.1327	0.1375
	0.0928	0.1072	0.1258	0.1467	0.1691	0.1923	0.2158	0.2390	0.2616	0.2832
7515	8.577	25.671	42.690	59.701	76.741	93.839	111.020	128.301	145.697	163.223
	0.1208	0.1166	0.1156	0.1162	0.1178	0.1206	0.1240	0.1278	0.1322	0.1371
	0.0928	0.1073	0.1258	0.1467	0.1691	0.1924	0.2159	0.2391	0.2617	0.2833
7518	8.601	25.722	42.739	59.741	76.771	93.857	111.025	128.290	145.668	163.176
	0.1224	0.1168	0.1152	0.1159	0.1174	0.1202	0.1234	0.1273	0.1316	0.1364
	0.0928	0.1073	0.1259	0.1467	0.1691	0.1924	0.2159	0.2392	0.2618	0.2834
7521	8.627	25.786	42.814	59.813	76.835	93.911	111.065	128.315	145.675	163.164
	0.1243	0.1176	0.1152	0.1156	0.1171	0.1197	0.1229	0.1267	0.1310	0.1357
	0.0928	0.1073	0.1259	0.1467	0.1691	0.1924	0.2159	0.2392	0.2618	0.2835
7524	8.666	25.886	42.949	59.961	76.983	94.056	111.204	128.443	145.752	163.265
	0.1270	0.1192	0.1161	0.1158	0.1171	0.1196	0.1226	0.1263	0.1305	0.1352
	0.0928	0.1073	0.1259	0.1467	0.1691	0.1924	0.2160	0.2392	0.2619	0.2836
7527	8.663	25.878	42.940	59.952	76.974	94.044	111.187	128.419	145.757	163.218
	0.1268	0.1192	0.1160	0.1158	0.1170	0.1194	0.1224	0.1260	0.1301	0.1347
	0.0929	0.1073	0.1259	0.1467	0.1691	0.1924	0.2160	0.2393	0.2619	0.2837
7530	8.650	25.847	42.902	59.911	76.932	94.000	111.141	128.368	145.700	163.153
	0.1259	0.1188	0.1159	0.1157	0.1170	0.1194	0.1223	0.1258	0.1298	0.1344
	0.0929	0.1073	0.1259	0.1467	0.1692	0.1925	0.2160	0.2393	0.2620	0.2838
7533	8.632	25.803	42.844	59.847	76.864	93.930	111.067	128.291	145.618	163.064
	0.1247	0.1181	0.1156	0.1155	0.1169	0.1193	0.1222	0.1256	0.1296	0.1341
	0.0930	0.1073	0.1259	0.1468	0.1692	0.1925	0.2160	0.2394	0.2620	0.2839
7536	8.617	25.770	42.803	59.796	76.804	93.862	110.991	128.206	145.524	162.960
	0.1236	0.1179	0.1152	0.1152	0.1166	0.1190	0.1219	0.1253	0.1293	0.1338
	0.0930	0.1C74	0.1259	0.1468	0.1692	0.1925	0.2161	0.2394	0.2621	0.2840
7539	8.626	25.790	42.823	59.807	76.805	93.850	110.965	128.165	145.466	162.885
	0.1242	0.1181	0.1150	0.1148	0.1162	0.1185	0.1214	0.1248	0.1287	0.1332
	0.0930	0.1074	0.1259	0.1468	0.1692	0.1925	0.2161	0.2394	0.2622	0.2841
7542	8.635	25.817	42.863	59.848	76.838	93.874	110.976	128.162	145.447	162.847
	0.1249	0.1188	0.1152	0.1146	0.1159	0.1181	0.1209	0.1242	0.1281	0.1325

	0.0930	0.1074	0.1259	0.1468	0.1692	0.1925	0.2161	0.2395	0.2622	0.2841
7545	8.657	25.872	42.934	59.922	76.908	93.937	111.030	128.203	145.473	162.857
	0.1264	0.1196	0.1156	0.1145	0.1157	0.1178	0.1205	0.1237	0.1276	0.1319
	0.0930	0.1074	0.1259	0.1468	0.1692	0.1925	0.2161	0.2395	0.2623	0.2842
7548	8.661	25.903	43.003	60.016	77.010	94.038	111.128	128.296	145.558	162.930
	0.1267	0.1212	0.1168	0.1151	0.1157	0.1178	0.1203	0.1235	0.1272	0.1314
	0.0931	0.1074	0.1259	0.1468	0.1692	0.1925	0.2161	0.2395	0.2623	0.2843
7551	8.657	25.893	42.990	60.002	76.996	94.023	111.111	128.274	145.529	162.892
	0.1264	0.1210	0.1167	0.1151	0.1157	0.1177	0.1202	0.1233	0.1269	0.1311
	0.0931	0.1074	0.1260	0.1468	0.1692	0.1926	0.2162	0.2395	0.2623	0.2843
7554	8.643	25.858	42.945	59.953	76.946	93.973	111.060	128.221	145.473	162.831
	0.1254	0.1205	0.1165	0.1150	0.1157	0.1177	0.1202	0.1232	0.1268	0.1309
	0.0931	0.1074	0.1260	0.1468	0.1692	0.1926	0.2162	0.2395	0.2623	0.2843
7557	8.623	25.806	42.876	59.876	76.866	93.891	110.977	128.137	145.387	162.743
	0.1240	0.1197	0.1161	0.1148	0.1156	0.1176	0.1201	0.1232	0.1267	0.1308
	0.0932	0.1074	0.1260	0.1468	0.1692	0.1926	0.2162	0.2396	0.2624	0.2844
7560	8.612	25.777	42.832	59.820	76.801	93.818	110.895	128.047	145.289	162.636
	0.1233	0.1191	0.1157	0.1145	0.1153	0.1173	0.1198	0.1229	0.1264	0.1305
	0.0932	0.1075	0.1260	0.1468	0.1693	0.1926	0.2162	0.2396	0.2624	0.2844

**** STATUS OF INTERATION COUNTERS ****

NUMBER OF ITERATIONS	1	2	3	4	5	6	7	8	9	10
SPZERO SUBROUTINE	0	4	0	0	0	0	0	0	0	0
DEWPT SUBROUTINE	0	0	92	102	21	0	0	0	0	0
EQLBRM SUBROUTINE	2	64	41	0	0	0	0	0	0	0

```
FINAL REPCRT OF:    SORGMDRY FANMANAGEMENT USING USCA TEST 1-N FOR FVALUATION OF FANMANAGEMENT     1

          GRAIN MOISTURE CONTENT(W.B.)          AVE:  0.1205  MAX:  0.1305     LAYER OBSERVED:   10

          PERCENT DRY MATTER LOSS (STEELE,69)   AVE:  C.1838  MAX:  0.2844     LAYER CBSERVED:   10

FAN OPERATION TIME SHEET(HOURS OF FAN OPERATION TO DATE)
                 NUMBER OF FILLS
                    1         2         3
           ---------------------------------
 LOW SPEED  |       0
 HIGH SPEED |     645

  DRYING STUDY DURATION:              645 HCURS
  FAN OPERATION                       645 HOURS
  HOURS OF NO FAN OPERATION:            0 HCURS


 ENERGY REQUIRED FOR FAN OPERATION TO DATE(KWH)
                 NUMBER OF FILLS
                    1         2         3
           ---------------------------------
 LOW SPEED  |   0.0
 HIGH SPEEC |  33.687

 TOTAL ENERGY REQUIRED FOR FAN CPERATION:   33.6867   KWH/FT2
 ENERGY FOR SUPPLEMENTAL HEATER:             0.0      KWH/FT2

 TOTAL ENERGY REQUIRED FOR THIS STUCY:      33.6867   KWH/FT2
```

APPENDIX C

Metric Conversions

Table C.1. SI (metric) conversions

To Convert From	To	Multiply By
Bushels	cubic meters	
Cubic feet	cubic meters	0.028317
Cubic feet/minute	cubic meters/second	0.000472
Cubic feet/minute bushel	cubic meters/second m^3	0.00013395
Cubic feet/minute sq. foot	cubic meters/second m^2	0.0050807
Fahrenheit degrees	celsius degrees	(F-32)/1.8
Feet	meters	0.3048
Hours	seconds	3,600
Inches	meters	0.0254
Inches of water	newtons/m^2 or pascals	248.84
Inches of water/foot	newtons/m^2m or pascals/m	816.40
Sq. feet	sq. meters	0.0929
Sq. inches	sq. centimeters	6.4510

ACKNOWLEDGMENTS

The author is deeply thankful to his major professor, Dr. Do S. Chung for his invaluable help and supervision in the preparation of this report. Appreciation is expressed to the staff of the Weather Data Library, Kansas Agricultural Experiment Station of Manhattan for the provision of weather data. The author expresses his appreciation to the Universidad Boliviana Gabriel R. Moreno and the Latin American Scholarship Program of American Universities for their financial assistance. The author is thankful to his graduate committee members, Dr. Larry E. Erickson and Dr. John R. Pedersen.

SIMULATION OF GRAIN SORGHUM DRYING BY NATURAL AIR

by

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Santa Cruz, Bolivia, 1976

AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

FOOD SCIENCE

Department of Agricultural Engineering

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1981

ABSTRACT

A computer program was used to predict the drying performance of grain sorghum by natural air in five different areas in the State of Kansas. Performance evaluations included grain deterioration (dry-matter-loss), final moisture content distribution and fan operation time. Effects of changes in yearly weather conditions on this drying method was also analyzed. Drying simulations were made for three years for the following weather stations: Topeka: 1963, 1965 and 1972, Dodge City: 1963, 1971 and 1972, Wichita: 1963, 1968 and 1972, Concordia: 1963, 1968 and 1972, and Goodland: 1963, 1966 and 1969. Tests were run for three initial grain moisture contents: 21%, 18% and 16% (w.b.) and various airflow rates and grain depths until the drying system was successful. The following conclusions were made based on the results that were obtained:

1. Drying systems that can work successfully: When a hot-dry year is expected, in all of the Districts of Kansas: For 21, 18 and 16% (w.b.) initial moisture contents, airflow rates of 1, 3/4 and ½ cfm/bu can be used with maximum grain depths of 16, 18 and 22 feet, respectively. But, when a cold-wet year is expected, two regions must be considered: (a) the West Central, Northwest, North Central and Northeast Districts: for 21, 18 and 16% (w.b.) initial moisture contents, airflow rates of 2, 1½ and 1 cfm/bu can be used with maximum grain depths of 15, 16 and 18 feet, respectively, and (b) the Southwest, South Central, Southeast, Central and East Central Districts: for 21, 18 and 16% (w.b.) initial moisture contents, airflow rates of 1½, 1 and 3/4 cfm/bu can be used with maximum grain depths of 16, 18 and 20 feet, respectively.

2. The amount of grain deterioration (dry matter loss) was higher for: higher drying air temperatures and initial moisture contents, lower airflow rates applied and longer drying periods.
3. Changes in yearly weather conditions can drastically change the results of the drying operation.