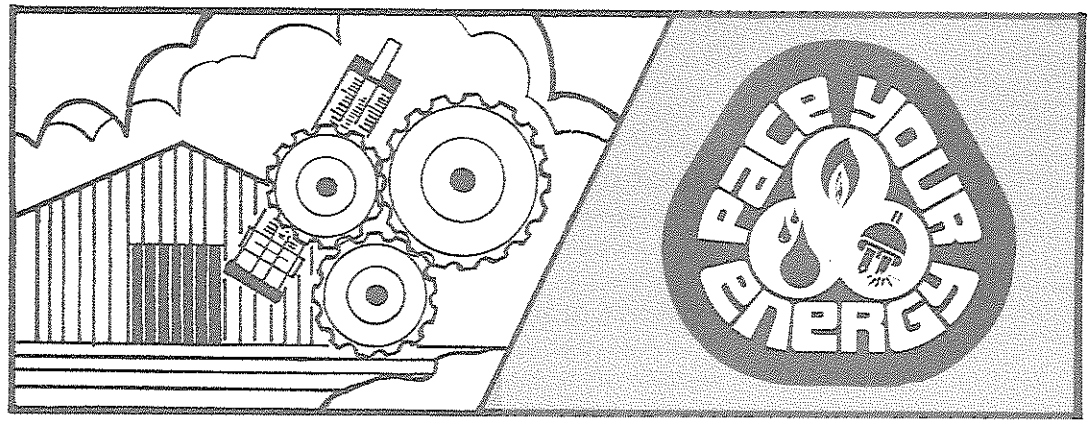
AEES-8

ENERGY IN AGRICULTURE

DRYERATION PERFORMANCE EVALUATION

Otto J. Loewer, T. C. Bridges, G. M. White,
Robert L. Fehr, and Larry W. Turner



UNIVERSITY of KENTUCKY
COLLEGE of AGRICULTURE
DEPT. of AGRIC. ENGINEERING
COOPERATIVE EXTENSION SERVICE

in
cooperation
with

KENTUCKY
DEPARTMENT
of
ENERGY

DRYERATION PERFORMANCE EVALUATION

Otto J. Loewer, T. C. Bridges, G. M. White, Robert L. Fehr, and Larry W. Turner

When grain is dried using continuous flow or portable batch dryers it must be cooled before it is placed in storage. The cooling process removes the sensible heat that was used to bring the grain temperature up to the drying air temperature, and hopefully reduces the grain temperature to a point where mold growth is no longer a problem. Unfortunately, rapid cooling of grain results in increased grain damage in terms of stress cracks, and is an energy-inefficient process in that the heat stored in the grain is not used for any useful purpose.

The dryeration process (McKenzie et al., 1972) is a method by which the capacity of a dryer can be increased, grain damage decreased and drying costs reduced along with increasing the energy efficiency of the drying system. The general recommendation for the dryeration process is to do no cooling in the dryer but to place nearly dry hot grain directly from a high temperature dryer into a holding bin and allow it to steep for a period of approximately 12 hours. During this "steeping time", moisture moves from the center of the grain kernels to the outside, and the air surrounding the kernels comes into moisture equilibrium with the grain. When relatively low amounts of air are moved through the grain (1/2 to 1 CFM/BU) the moisture is removed until finally the grain reaches moisture equilibrium with the air used for cooling. This process can result in several additional points of moisture being removed from the grain.

To determine how effective the dryeration process might be for your situation, complete the following form and return to

Dr. Otto J. Loewer
Associate Extension Professor
Agricultural Engineering Department
University of Kentucky
Lexington, KY 40506

1. **NAME**

2. **ADDRESS**

3. **PHONE NUMBER**

4. **TYPE OF GRAIN DRIED**
(corn or milo)

5. **TEMPERATURE OF OUTSIDE AIR**
This needs to be at least 20°F cooler than the temperature of the grain entering the dryeration bin.

6. **RELATIVE HUMIDITY OF OUTSIDE AIR**
Note that if the relative humidity is sufficiently high, little additional moisture will be removed from the grain.

7. **TEMPERATURE OF THE GRAIN IN THE DRYERATION BIN**
Typically, the grain would be 20-30°F cooler than when it left the dryer.

8. PERCENT MOISTURE CONTENT OF THE GRAIN AFTER DRYING AND BEFORE DRYERATION

A typical value would be 15 to 18 percent.

9. DESIRED FINAL PERCENT MOISTURE CONTENT OF THE GRAIN AFTER DRYERATION

10. CUBIC FT. PER MINUTE OF AIR SUPPLIED BY THE FAN TO EACH BUSHEL OF GRAIN IN THE BIN (CFM/BU)

Typical values are 1/2 to 1 CFM/BU. Consult other programs to obtain more exact figures for your system.

The computer analysis you will receive will be similar to that shown below. Each term is defined below the sample output.

```
CORN, MILO OR STOP
?CORN -1
  2          3          4             5     6     7
AIR TEMP, REL.HUM, GRAIN TEMP, WBO, WBF, CFM/BU
?65         60        140          16    13    0.5

CORN -1
NATURAL AIR DRYING
 8       9        10       11        12      13       14       15
TIME   WB(1)   WBAVE   WB(10)    G(1)    GAVE     G(10)    %DM
 2.75  14.07   14.99   15.60    76.92   110.72   129.27   0.0192
 5.50  13.78   14.41   15.02    66.72    92.72   112.81   0.0251
 8.25  13.68   14.09   14.58    64.17    82.15    99.75   0.0268
11.00  13.63   13.90   14.29    63.51    75.58    90.41   0.0275
13.75  13.59   13.78   14.08    63.37    71.19    83.30   0.0279
16.50  13.56   13.70   13.91    63.49    68.27    77.10   0.0281
18.15  13.53   13.67   13.84    63.44    67.06    74.47   0.0282
TOP LAYER COOLED TO WITHIN 10 DEGREES OF AMBIENT -16
```

1. CORN—Type of grain to be dried (Question 4).
2. AIR TEMP—Temperature of the outside air (Question 5).
3. REL HUM—Percentage relative humidity of the outside air (Question 6).
4. GRAIN TEMP —The temperature of the grain before dryeration (Question 7).
5. WBO—The percentage moisture content of the grain after drying and before dryeration (Question 8).
6. WBF—The desired final moisture content percentage of the grain after dryeration (Question 9).
7. CFM/BU—The airflow rate per bushel supplied by dryeration fan (Question 10).
8. TIME—The time in hours after the dryeration process begins, i.e., when the dryeration fan was turned on.
9. WB(1)—The percent moisture content of the grain next to where the outside air enters the bin for a given point in time.
10. WBAVE—The average percent moisture content of the grain in the bin for a given point in time.
11. WB(10)—The percent moisture content of the grain at the point where the outside air exits the grain at a given point in time.
12. G(1)—The temperature of the grain next to where the outside air enters the grain for a given point in time.
13. GAVE—The average temperature of the grain in the bin for a given point in time.
14. G(10)—The temperature of the grain next to where the outside dryeration air exits the grain for a given time.
15. % DM—The percentage of dry matter decomposition. When this value reaches 0.5%, the market grade will be lowered to the next level. When it reaches 1%, the grain will have spoiled.
16. TOP LAYER COOLED—This statement indicates that the grain temperature has nearly reached equilibrium with the outside air. In other words, the air cannot continue drying the grain. If moisture content reaches equilibrium before temperature does, the statement would read "PROGRAM STOPPED BECAUSE WB(10) APPROACHES ME."

ENERGY CONSUMPTION:

The energy used in the dryeration process is limited to operating the fan. The amount of electricity used in fan operation may be determined through the program "Fan Performance on Grain Drying Bins". An estimate of energy consumption may be made from the following equation:

$$\left(\begin{matrix}\text{KW-hr of}\\ \text{Electrical Energy}\end{matrix}\right) \cong \left(\begin{matrix}\text{Horsepower of}\\ \text{fan}\end{matrix}\right) \times \left(\begin{matrix}\text{Hours of}\\ \text{operation}\end{matrix}\right)$$

where 1 hp $\cong$ 1000 watts. The hours of operation can be determined from the analysis of your system. For example, 18.15 hours of fan operation were required to dry the grain from the sample analysis. Therefore, if we assume a 2.5 hp fan was used:

$$\text{KW-hr} \cong 2.5 \times 18.15 = 45.4 \text{ KW-hr}$$

If electricity costs $0.03 KW-hr, the cost for dryeration would be $1.36.

SUMMARY:

The dryeration process is an energy-saving procedure. The amount of energy that may be saved depends on the dryer characteristics. This quantity may be calculated using other programs that are available and drying down only to the point where dryeration can remove the remaining moisture to a point safe for storage. Dryeration will improve the quality of the grain and increase the drying capacity of the dryer by removing the need for the cooling section. It is suggested that a separate bin be used for the dryeration process in order to keep water from condensing on the walls of the storage bins and perhaps creating storage problems at a later time. However, many farmers report that they are placing the hot grain directly into storage and then applying the dryeration process successfully. The dryeration fan should blow air up through the grain in the bin to prevent pulling hot high moisture air through the cooled grain.

AVAILABLE PROGRAMS:

1. BNDZN: Computer analysis of economics, energy consumption and engineering design of a grain storage system.
2. CHASE: Computer model that evaluates and compares costs of selected methods of harvesting, handling, drying and storage of corn for an individual farmstead. Energy consumption is also estimated.
3. CACHE: Computer model for economic analysis of farm drying and processing systems.
4. SQUASH: Computer simulation of the harvesting-delivery-drying system used to determine bottlenecks in the system.

*5. ESTIMATING FAN SIZES FOR GRAIN DRYING SYSTEMS
*6. GRAIN DRYING PERFORMANCE EVALUATION
*7. DRYERATION PERFORMANCE EVALUATION
*8. NATURAL AIR-LOW TEMPERATURE DRYING PERFORMANCE EVALUATION
*9. FAN PERFORMANCE ON GRAIN DRYING BINS

ACKNOWLEDGEMENTS:

*These programs were developed by:

Dr. Thomas L. Thompson, Professor
Agricultural Engineering Department
University of Nebraska
Lincoln, Nebraska

REFERENCE:

McKenzie, B.A., G. H. Foster, R. T. Noyes, and R. A. Thompson, 1972. "Dryeration–Better Corn Quality with High Speed Drying." Cooperative Extension Service Bulletin, Purdue University, West Lafayette, Ind.

Issued 10-78, 3M; 1.5M–11-81