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RICE DRIER OPERATORS GUIDE

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The information presented here is a supplement to the mimeographed report "Drying Combined Rice" put out in July 1948 by Harold A. Kramer from the Rice-Pasture Experiment Station. Some of the information is a result of research conducted since the writing of this report.

COMBINING RICE FOR DRYING

When Should Rice be Combined for Best Milling Results?

A maturity quality study conducted during the 1949 harvest indicated that the following moisture range and total days since emergence produced optimum results:

Variety	Moisture range, %	Days since emergence
Caloro	26-21	108-118
Zenith	25-19	110-120
Bluebonnet	25-16	122-133
Rexoro	22-18	153-161

This summary was made from the results of 12 series of tests and 217 harvesting dates on small hand-harvested, replicated plots.

What Effect Does Improper Combine Operation and Cylinder Spacing Have on Milling Quality?

A study made of 152 typical samples of combined rice, which had been artificially dried, showed that the following percentages of hulled grains were checked or broken: La Cross, 44; Fortuna, 63; Bluebonnet, 68; Rexoro, 54; R. N., 68; Nira, 69; Patna, 66; Zenith, 43; and Magnolia, 35.

This indicates the importance of proper combining to reduce the number of hulled grains to a minimum.

A study with typical samples of combined rice showed the following average and variation in the amount of hulled rice and trash received at driers:

Variety	Percent hulled rice			Percent trash		
	Av.	Max.	Min.	Av.	Max.	Min.
Bluebonnet	5.3	10.6	1.5	0.5	1.6	0.05
Patna	4.5	14.2	1.3	0.6	2.0	0.14
Nira	4.6	5.3	3.6	0.3	0.4	0.14
R. N.	3.0	5.4	0.9	0.3	0.6	0.13
Zenith	4.6	13.1	0.1	0.7	3.7	0.06
Rexoro	3.4	9.2	0.3	0.9	3.0	0.10
Magnolia	7.6	11.5	0.5	0.7	4.0	0.10
La Cross	3.7	4.9	2.2	2.4	3.0	1.80
Fortuna	4.0	4.7	2.9	0.9	1.7	0.14

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The wide range in the amount of hulled rice and trash which arrive at the drier indicates that all combines are not operated with equal efficiency. Results of research in Arkansas show that there is more difference in the rice sample produced by different operators than that produced by different makes of combines. All combine operators should be encouraged to follow the combine manufacturers instructions and maintain correct adjustment and speed of the cylinder. Short lengths of straw in the rice can be minimized by raising the cutter bar at the completion of a cut.

Should Combined Rice Be Cleaned Before Drying?

It is highly desirable that rice be cleaned before drying and between dryings to remove straw, grass and weeds, which usually contain a higher percentage of moisture than rice.

A coarse screen is probably best for removing the larger pieces of straw and other material which interfere with the uniform flow of rice. One of the best commercial cleaners observed uses a revolving screen cylinder for removing the larger pieces of straw and an air blast for the smaller and lighter dust, chaff and hulls.

How Soon After Combining Should Drying Begin?

There is no reason for delaying the drying any longer than necessary. The maximum permissible period between combining and drying depends largely on the temperature and moisture content of the rice.

In general, drying should begin within 6 hours after combining. This includes small partial truck loads of high moisture rice which farmers often store temporarily in a combine hopper or truck. Such rice usually heats rapidly and developes a "sour" condition. When added to a good lot, such rice may cause the entire lot to go out of condition in a short time.

OPERATION OF RICE DRIERS

What Is the Proper Drying Temperature?

A guide for the selection of drying air temperatures in relation to rice moisture content and atmospheric conditions was prepared by W. D. Smith, rice supervisor of the U. S. Department of Agriculture. Drier operators who have followed these tables carefully have found them to be an excellent guide. Following is a condensed copy of the original tables.

Directions for Using the Tables

Determine the moisture content of the rice before drying.

Determine the dry and wet bulb temperatures of the atmosphere.

Turn to the table which gives the atmospheric temperature (dry bulb reading).

Use the column of figures under the wet bulb reading.

The exact temperature of the heated air to be used for drying the rice will then be established by using the figure in the column opposite the figure showing the moisture of the rice.

Example:

The atmospheric temperature (dry bulb reading) is 80.

The wet bulb temperature of the atmosphere is 72.

The moisture content of the rice is 18.4 percent.

The temperature of the heated air to be used in drying the rice is 120° F.

Atmospheric temperature—60° F.

Moisture content of rice	Wet bulb and drying temperatures					
Percent	59 58	57 56	55 54 53 52	51 50 49	48 47 46	45
16.0 and under	106	105	104	103	102	101
16.1 and 16.2	107	106	105	104	103	102
16.3 and 16.4	108	107	106	105	104	103
16.5 and 16.6	109	108	107	106	105	104
16.7 and 16.8	110	109	108	107	106	105
16.9 and 17.0	111	110	109	108	107	106
17.1 and 17.2	112	111	110	109	108	107
17.3 and 17.4	113	112	111	110	109	108
17.5 and 17.6	114	113	112	111	110	109
17.7 and 17.8	115	114	113	112	111	110
17.9 and 18.0	116	115	114	113	112	111
18.1 and 18.2	117	116	115	114	113	112
18.3 and 18.4	118	117	116	115	114	113
18.5 and 18.6	119	118	117	116	115	114
18.7 and 18.8	120	119	118	117	116	115
18.9 and over	121	120	119	118	117	116

Atmospheric temperature—65° F.

Moisture content of rice	Wet bulb and drying temperatures					
Percent	64 63	62 61	60 59 58	57 56 55 54	53 52	51 50
16.0 and under	107	106	105	104	103	102
16.1 and 16.2	108	107	106	105	104	103
16.3 and 16.4	109	108	107	106	105	104
16.5 and 16.6	110	109	108	107	106	105
16.7 and 16.8	111	110	109	108	107	106
16.9 and 17.0	112	111	110	109	108	107
17.1 and 17.2	113	112	111	110	109	108
17.3 and 17.4	114	113	112	111	110	109
17.5 and 17.6	115	114	113	112	111	110
17.7 and 17.8	116	115	114	113	112	111
17.9 and 18.0	117	116	115	114	113	112
18.1 and 18.2	118	117	116	115	114	113
18.3 and 18.4	119	118	117	116	115	114
18.5 and 18.6	120	119	118	117	116	115
18.7 and 18.8	121	120	119	118	117	116
18.9 and over	122	121	120	119	118	117

Atmospheric temperature—70° F.

Moisture content of rice	Wet bulb and drying temperatures					
Percent	69 68	67 66 65	64 63 62	61 60	59 58 57	56 55
16.0 and under	108	107	106	105	104	103
16.1 and 16.2	109	108	107	106	105	104
16.3 and 16.4	110	109	108	107	106	105
16.5 and 16.6	111	110	109	108	107	106
16.7 and 16.8	112	111	110	109	108	107
16.9 and 17.0	113	112	111	110	109	108
17.1 and 17.2	114	113	112	111	110	109
17.3 and 17.4	115	114	113	112	111	110
17.5 and 17.6	116	115	114	113	112	111
17.7 and 17.8	117	116	115	114	113	112
17.9 and 18.0	118	117	116	115	114	113
18.1 and 18.2	119	118	117	116	115	114
18.3 and 18.4	120	119	118	117	116	115
18.5 and 18.6	121	120	119	118	117	116
18.7 and 18.8	122	121	120	119	118	117
18.9 and over	123	122	121	120	119	118

Atmospheric temperature—75° F.

Moisture content of rice	Wet bulb and drying temperatures						
Percent	74	73 72	71 70	69 68 67	66 65	64 63 62	61 60
16.0 and under	110	109	108	107	106	105	104
16.1 and 16.2	111	110	109	108	107	106	105
16.3 and 16.4	112	111	110	109	108	107	106
16.5 and 16.6	113	112	111	110	109	108	107
16.7 and 16.8	114	113	112	111	110	109	108
16.9 and 17.0	115	114	113	112	111	110	109
17.1 and 17.2	116	115	114	113	112	111	110
17.3 and 17.4	117	116	115	114	113	112	111
17.5 and 17.6	118	117	116	115	114	113	112
17.7 and 17.8	119	118	117	116	115	114	113
17.9 and 18.0	120	119	118	117	116	115	114
18.1 and 18.2	121	120	119	118	117	116	115
18.3 and 18.4	122	121	120	119	118	117	116
18.5 and 18.6	123	122	121	120	119	118	117
18.7 and 18.8	124	123	122	121	120	119	118
18.9 and over	125	124	123	122	121	120	119

Atmospheric temperature--80° F.

Moisture content of rice	Wet bulb and drying temperatures						
Percent	79 78	77 76	75 74	73 72 71	70 69	68 67 66	65
16.0 and under	111	110	109	108	107	106	105
16.1 and 16.2	112	111	110	109	108	107	106
16.3 and 16.4	113	112	111	110	109	108	107
16.5 and 16.6	114	113	112	111	110	109	108
16.7 and 16.8	115	114	113	112	111	110	109
16.9 and 17.0	116	115	114	113	112	111	110
17.1 and 17.2	117	116	115	114	113	112	111
17.3 and 17.4	118	117	116	115	114	113	112
17.5 and 17.6	119	118	117	116	115	114	113
17.7 and 17.8	120	119	118	117	116	115	114
17.9 and 18.0	121	120	119	118	117	116	115
18.1 and 18.2	122	121	120	119	118	117	116
18.3 and 18.4	123	122	121	120	119	118	117
18.5 and 18.6	124	123	122	121	120	119	118
18.7 and 18.8	125	124	123	122	121	120	119
18.9 and over	126	125	124	123	122	121	120

Atmospheric temperature--85° F.

Moisture content of rice	Wet bulb and drying temperatures							
Percent	84	83 82	81 80	79 78	77 76	75 74 73	72 71	70
16.0 and under	113	112	111	110	109	108	107	106
16.1 and 16.2	114	113	112	111	110	109	108	107
16.3 and 16.4	115	114	113	112	111	110	109	108
16.5 and 16.6	116	115	114	113	112	111	110	109
16.7 and 16.8	117	116	115	114	113	112	111	110
16.9 and 17.0	118	117	116	115	114	113	112	111
17.1 and 17.2	119	118	117	116	115	114	113	112
17.3 and 17.4	120	119	118	117	116	115	114	113
17.5 and 17.6	121	120	119	118	117	116	115	114
17.7 and 17.8	122	121	120	119	118	117	116	115
17.9 and 18.0	123	122	121	120	119	118	117	116
18.1 and 18.2	124	123	122	121	120	119	118	117
18.3 and 18.4	125	124	123	122	121	120	119	118
18.5 and 18.6	126	125	124	123	122	121	120	119
18.7 and 18.8	127	126	125	124	123	122	121	120
18.9 and over	128	127	126	125	124	123	122	121

Atmospheric temperature—90° F.

Moisture content of rice	Wet bulb and drying temperatures							
Percent	89	88 87	86	85 84 83	82 81	80 79	78 77	76 75
16.0 and under	115	114	113	112	111	110	109	108
16.1 and 16.2	116	115	114	113	112	111	110	109
16.3 and 16.4	117	116	115	114	113	112	111	110
16.5 and 16.6	118	117	116	115	114	113	112	111
16.7 and 16.8	119	118	117	116	115	114	113	112
16.9 and 17.0	120	119	118	117	116	115	114	113
17.1 and 17.2	121	120	119	118	117	116	115	114
17.3 and 17.4	122	121	120	119	118	117	116	115
17.5 and 17.6	123	122	121	120	119	118	117	116
17.7 and 17.8	124	123	122	121	120	119	118	117
17.9 and 18.0	125	124	123	122	121	120	119	118
18.1 and 18.2	126	125	124	123	122	121	120	119
18.3 and 18.4	127	126	125	124	123	122	121	120
18.5 and 18.6	128	127	126	125	124	123	122	121
18.7 and 18.8	129	128	127	126	125	124	123	122
18.9 and over	130	129	128	127	126	125	124	123

Atmospheric temperature—95° F.

Moisture content of rice	Wet bulb and drying temperatures								
Percent	94	93	92 91	90 89	88 87	86 85	84 83	82 81	80
16.0 and under	117	116	115	114	113	112	111	110	109
16.1 and 16.2	118	117	116	115	114	113	112	111	110
16.3 and 16.4	119	118	117	116	115	114	113	112	111
16.5 and 16.6	120	119	118	117	116	115	114	113	112
16.7 and 16.8	121	120	119	118	117	116	115	114	113
16.9 and 17.0	122	121	120	119	118	117	116	115	114
17.1 and 17.2	123	122	121	120	119	118	117	116	115
17.3 and 17.4	124	123	122	121	120	119	118	117	116
17.5 and 17.6	125	124	123	122	121	120	119	118	117
17.7 and 17.8	126	125	124	123	122	121	120	119	118
17.9 and 18.0	127	126	125	124	123	122	121	120	119
18.1 and 18.2	128	127	126	125	124	123	122	121	120
18.3 and 18.4	129	128	127	126	125	124	123	122	121
18.5 and 18.6	130	129	128	127	126	125	124	123	122
18.7 and 18.8	131	130	129	128	127	126	125	124	123
18.9 and over	132	131	130	129	128	127	126	125	124

How Many Times Should Rice Pass Through the Drier?

Rice which has been combined at moistures above 20 percent should be dried about four times. Usually it is desirable to remove all the moisture above 19 percent in the first drying. The second drying should remove 2 to 3 percent and the remaining dryings from 1 to 2 percent.

Rice of excellent milling quality has been produced by drying it continuously in one operation with low temperature drying air. The capacity of most driers is reduced when this procedure is used with rice of high initial moisture content.

How Long Should Rice Remain in the Drier?

A drying period of 30 minutes for rice up to 23 percent moisture has been suggested by W. D. Smith, rice supervisor, for the U. S. Department of Agriculture. For each percent moisture above 23, he suggests increasing the drying period an additional 9 minutes. For example:

Up to 23% - 30 minutes	Up to 27% - 66 minutes
24% - 39 minutes	28% - 75 minutes
25% - 48 minutes	29% - 84 minutes
26% - 57 minutes	30% - 93 minutes

What Is the Proper Length of Time Between Dryings?

The occurrence of "stackburn" can best be prevented by limiting the time between dryings. The practice of deliberately allowing the temperature of rice to rise in a bin between dryings is not recommended.

Maximum drier capacity is obtained if rice is returned to a bin as soon as the hull moisture has been removed. While in the bin, the interior moisture will diffuse into the dry hull. Equilibrium is usually reached in 12 to 24 hours, and the rice is then ready for an additional drying.

In general, at higher moistures, the second drying should occur sooner than the following dryings. This is due to the "drier heat" usually contained by rice immediately after the first drying.

To What Moisture Content Should Rice Be Dried?

Rice which will be stored in bulk up to 6 months should not have a moisture content greater than 13 percent. Because rice leaving a drier is seldom uniform in moisture content, it is necessary to dry until the average moisture is less than 13 percent to insure that no portion of the lot will have excess moisture. Variations of 1 to 2 percent moisture are commonly found within a lot.

Do Different Varieties of Rice Dry Differently?

Several interrelated factors such as size of grain, slenderness and thickness of hull, affect the rate at which a variety will lose moisture. Laboratory tests with four varieties have shown that Bluebonnet dries most easily, Rexoro and Zenith about the same, and Caloro is the slowest.

Should Rice Be Cooled After Drying?

There probably is no advantage in cooling rice between dryings unless it is anticipated there will be an unusually long delay before the next drying period occurs.

If rice is to be kept in storage, it should be cooled with unheated air as the last step in drying. The final cooling preferably should be done when the humidity is below saturation. However, no increase in moisture content will occur as long as the temperature of the rice is above atmospheric temperature.

Replicated tests have shown that dry rice can be rapidly cooled to 40° F. in a drier with cold atmospheric air without decreasing milling quality.

HANDLING RICE AT DRYING PLANTS

Can Small Lots of Undried or Partly-dried Rice of the Same Variety, Type and Quality Be Mixed Safely in One Large Bin?

Small lots of rice should be mixed whenever possible. By simultaneously discharging from each bin to one common conveyor, or from the drier and a bin to one conveyor, a reasonably uniform mix is obtained.

What Should Be Done to Obtain Uniformity in a Lot of Rice?

It is difficult to mix a large lot of rice uniformly. Transferring from one bin to another is not always adequate. A better method is to place the rice in two or more bins and then simultaneously discharge from all bins to one conveyor.

A lot of rice which is not uniform throughout cannot be dried and stored as satisfactorily as a uniform lot.

Should Rice Be Milled Immediately After Drying?

Artificially-dried rice should be cooled to atmospheric temperature and stored at least a week before it is milled.

Will the Moisture Content of Rice Increase After Drying?

Artificially-dried rice will not increase its moisture content to any greater extent than other rice, when exposed to the same conditions. There are cases where apparent increases in moisture content have occurred where rice was properly protected from outside sources of moisture. These apparent increases may be attributed to errors in taking the moisture samples, to errors in the moisture tests, or to both.

LOSS OF WEIGHT IN DRYING

How Much Weight Is Lost When Rice Is Dried?

When rough rice is dried artificially, or dried naturally in the shock in the field, there always is a loss of weight. This loss is due to the removal of moisture, and the percentage loss of weight due to drying always is greater than the reduction in the percentage of moisture. This difference exists because, as the rice is being dried, there is a constant change of base in expressing the moisture percentage.

Percentage of shrinkage in weight of rough rice when the loss in moisture and the original moisture content are known. (Due to loss of water only—does not include losses due to removal of foreign matter)

Loss in moisture	Original moisture content, %							
	14	15	16	17	18	19	20	21
1 percent	1.15	1.16	1.18	1.19	1.20	1.22	1.23	1.25
2 percent	2.27	2.30	2.32	2.35	2.38	2.41	2.44	2.47
3 percent	3.37	3.41	3.45	3.49	3.53	3.57	3.61	3.66
4 percent	4.44	4.49	4.54	4.60	4.65	4.70	4.76	4.82
5 percent	5.49	5.55	5.62	5.68	5.75	5.81	5.88	5.95
6 percent	6.52	6.59	6.67	6.74	6.82	6.90	6.98	7.06
7 percent	7.53	7.61	7.69	7.78	7.86	7.95	8.04	8.14
8 percent	8.51	8.60	8.69	8.79	8.89	8.99	9.09	9.19
9 percent	9.47	9.57	9.68	9.78	9.89	10.00	10.11	10.23
10 percent	10.42	10.53	10.64	10.75	10.87	10.99	11.11	11.23
11 percent	11.34	11.46	11.58	11.70	11.83	11.96	12.09	12.22
12 percent	12.24	12.37	12.50	12.63	12.76	12.90	13.04	13.19

	22	23	24	25	26	27	28	29
1 percent	1.26	1.28	1.30	1.31	1.33	1.35	1.37	1.39
2 percent	2.50	2.53	2.56	2.60	2.63	2.67	2.70	2.74
3 percent	3.70	3.75	3.80	3.85	3.90	3.95	4.00	4.05
4 percent	4.88	4.94	5.00	5.06	5.13	5.19	5.26	5.33
5 percent	6.02	6.10	6.17	6.25	6.33	6.41	6.49	6.58
6 percent	7.14	7.23	7.32	7.41	7.50	7.59	7.69	7.79
7 percent	8.23	8.33	8.43	8.54	8.64	8.75	8.86	8.97
8 percent	9.30	9.41	9.52	9.64	9.76	9.88	10.00	10.13
9 percent	10.34	10.46	10.59	10.71	10.84	10.97	11.11	11.25
10 percent	11.36	11.49	11.63	11.76	11.90	12.05	12.19	12.34
11 percent	12.36	12.50	12.64	12.79	12.94	13.09	13.25	13.41
12 percent	13.33	13.48	13.64	13.79	13.95	14.12	14.28	14.46
13 percent	14.28	14.44	14.61	14.77	14.94	15.12	15.29	15.48
14 percent	15.22	15.38	15.55	15.73	15.91	16.09	16.28	16.47
15 percent	16.13	16.30	16.48	16.67	16.85	17.04	17.24	17.44
16 percent	17.02	17.20	17.39	17.58	17.78	17.98	18.18	18.39
17 percent	17.89	18.08	18.28	18.48	18.68	18.89	19.10	19.32
18 percent	18.75	18.95	19.15	19.35	19.56	19.78	20.00	20.22
19 percent	19.59	19.79	20.00	20.21	20.43	20.65	20.88	21.11
20 percent	20.41	20.62	20.83	21.05	21.28	21.50	21.74	21.98

Calculations for the final weight of a barrel of rice after drying may be made as follows:

$$\text{Final weight} = \frac{(\text{Original wt.})\ (\text{original percent dry matter})}{\text{final percent dry matter}}$$

As an example, assume 162 pounds of rice were dried from 24 percent to 14 percent:

$$\text{Final weight} = \frac{(162\ \text{lbs.})\ (100\% - 24\%)}{(100\% - 14\%)} = 143.2\ \text{pounds}$$

In this case, the moisture was reduced from 24 to 14 percent while the reduction in weight due to drying is 11.6 percent of the initial weight.

In addition to the weight lost due to drying, there usually is some loss in weight due to the blowing out of small particles of broken grains, dust and hulls. Where the rice is cleaned during the drying process, additional straw, weed seeds and foreign material are removed.

MOISTURE TESTS

How Are Accurate Moisture Tests Made?

To determine accurately the moisture content of a lot of rice it first is necessary to obtain a representative sample of the entire lot. This is difficult, as the moisture content of a lot usually varies considerably. An average sample may be obtained by collecting small portions at equal intervals as the rice is being transferred.

The Brown-Duvel tester, if properly operated, will give the true moisture of a sample of rice, regardless of foreign matter, temperature of the rice or uniformity of drying. Tests conducted by the Grain Research Laboratory, Board of Grain Commissioners for Canada, Winnipeg, Manitoba, show that an error of 0.15 percent may be expected, which is considerably less than for electric meters. Complete instructions for the operation of this tester are given in USDA Bulletin No. 1375D, "The Brown-Duvel Moisture Tester and How to Operate It."

The principal advantage of the electric type tester is in the rapidity with which tests can be made. For this reason, they are popular with rice drier operators, who need to know at all times the approximate moisture content of each lot of rice. These testers are calibrated with clean rice of uniform moisture content and, when testing such rice, are very accurate. Wet-combined rice is seldom uniform in moisture content, which makes it difficult to obtain a true average moisture reading. Rice which has just passed through a drier is not of uniform moisture throughout the entire grain and, unless allowance for this is made, the true moisture is not obtained. For this reason, some drier operators believe the moisture content of rice changes appreciably while in the bin between dryings.

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