

Grain Storage Tips

Factors and Formulas for Crop Drying, Storage and Handling

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For best success in storing grain:

- Clean grain to remove chaff, weed seeds, and broken kernels.
- Handle grain gently to minimize cracked and broken kernels.
- Store grain at the recommended moisture.
- Aerate stored grain to maintain a cool, uniform, recommended temperature.
- Check stored grain frequently and take immediate action to eliminate problems.

Volume Bushels (all measurements in feet):

Bushels shelled grain (bu) = 0.8 x cubic feet (cu.ft.)

Bushels ear corn (bu) = 0.4 x cubic feet (cu.ft.)

Rectangular bin volume (cu.ft.) = length x width x height

Cylindrical bin volume = $0.785 \times \text{diameter}^2 \times \text{height}^*$

Cone volume = $0.262 \times \text{diameter}^2 \times \text{height}^*$

Pyramid volume = $0.333 \times \text{length} \times \text{width} \times \text{height}$

Pile height = tangent of angle repose x [0.5 x rectangular pile width or round pile diameter]

[* diameter² = diameter x diameter]

Bushels by Weight

Crop	Bushel Weight (lb)	Moisture Content (% wet basis)
Barley	48	14.5
Shelled corn	56	15.5
Oats	32	14.0
Soybeans	60	13.0
Sunflowers (oil)	30	10.0
Sunflowers (confectionery)	24	10.0
Wheat	60	13.5

Wet bushels (bu) = total weight (lb) ÷ bushel weight (lb/bu)

Dry bushels (bu) = wet bushels (bu) x [(100 - total moisture shrink) ÷ 100]

[Measured test weight of grain is not used in calculating bushels by weight.]

Angle of Repose

Crop	Angle (degrees)	Tangent
Barley	28	0.53
Shelled corn	23	0.42
Oats	28	0.53
Soybeans	25	0.47
Sunflowers	27	0.51
Wheat	25	0.47

[Also see publication *Calculating Bushels*, or <http://www.bae.umn.edu/extens/postharvest/bushels.html>]

Moisture and Shrink Factors:

Moisture shrink factor (% weight loss per % of moisture loss) = $100 \div (100 - \text{final moisture})$

Example (to adjust to 15% moisture):

$$100 \div (100 - 15) = 100 \div 85 = 1.176\% \text{ per point.}$$

[Commercial grain buyers usually add a handling loss factor to the moisture shrink factor. Typical commercial shrink factors are 1.25 to 1.5% per point for corn and 1.5 to 2% per point for soybeans.]

Moisture shrink (% weight) = points of moisture difference x moisture shrink factor

Dry matter (lb) = wet weight (lb)

$$\times [(100 - \text{wet basis moisture content}) \div 100]$$

Airflow Recommendations:

- Aerating dry grain, about 0.1 cubic feet of air per minute per bushel of grain (cfm/bu)
- Cooling hot grain in storage, about 12 cfm per bu/hr of dryer capacity.
- Natural-air drying, about 1 cfm/bu for 22% moisture corn or 18% moisture soybeans or 18% moisture small grains.
- Cooling time (hr) = $15 \div \text{airflow per bushel (cfm/bu)}$
- Natural-air drying time, about 4 to 6 weeks depending on the weather and initial crop moisture.

[See Minnesota Extension publications *Natural-Air Drying in the Upper Midwest*, BU-6577, and *Wheat and Barley Drying*, FS-5949.]

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High Temperature Drying:

Propane use equals about 0.02 gal/bu per percentage point of moisture removed.

Keep kernel temperature under 110°F to preserve germination, under 140°F to preserve milling quality.

Fan Power Requirement:

Depends on airflow, grain type and grain depth.

[See the Minnesota Extension publication *Selecting Fans and Determining Airflow for Crop Drying, Cooling and Storage*, FO-5716. A computer program is also available for download in the "Biosystems and Agricultural Engineering Department Materials" software section of:
<http://www.bae.umn.edu/extens/postharvest/>]

Recommended Vent and Duct Sizes:

Bin roofs should have about 1 square foot of open area per 1,000 cubic feet per minute (cfm) of airflow. Add roof vents if the gap at eaves and the hatches open during fan operation do not provide enough area.

Provide 1 square foot of duct cross-sectional area per 1,500 cfm of airflow.

Cross-sectional area for round ducts (sq. ft.)
 = 0.00545 x diameter (in.) x diameter (in.)

Cross sectional area for common round duct sizes:

Diameter (inches)	12	18	24
Area (square feet)	0.78	1.77	3.14

Recommended Storage Temperature and Moisture:

Keep grain temperature less than 50°F at all times of the year.

In the upper Midwest, aerate to cool grain to 20° to 30°F for winter storage.

Recommended Storage Moisture (percent wet basis for clean, aerated grain crops)

	Storage Time	
	Up to 6 Months	More than 6 Months
Corn	15	13
Soybeans	13	11
Canola	15	13
Edible beans	15	13
Small grains	14	13
Sunflower (oil)	10	8

Recommended Spout and Floor Angles

Angle with horizontal (degrees) required for gravity flow on sloped surfaces:

Material	Angle (degrees)
Grain (dry, cool)	37
Grain (wet, hot)	45
Ground feed or meal	60
Pellets	45
Sunflowers	60

Maximum storage time in months for shelled corn *

Corn Temp.	Corn Moisture Content					
	13%	14%	15%	16%	17%	18%
40°F	150	61	29.0	15.0	9.5	6.1
50°F	84	34	16.0	8.9	5.3	3.5
60°F	47	19	9.2	5.0	3.0	1.9
70°F	26	11	5.2	2.8	1.7	1.1
80°F	15	6	2.9	1.6	0.9	0.9

[*Based on 0.5% maximum dry matter loss – calculated on the basis of USDA research at Iowa State University.]

Equilibrium Moisture Values

Moisture content (% wet basis) for crops exposed to air at various temperatures and relative humidities.

Temperature (°F)	Relative Humidity											
	20 %			40 %			60 %			80 %		
	C	W	SB	C	W	SB	C	W	SB	C	W	SB
40	9.2	8.5	4.6	11.9	11.7	8.1	14.5	14.6	11.5	17.9	18.0	16.0
50	8.5	8.2	4.2	11.2	11.3	7.8	13.8	14.2	11.2	17.3	17.4	15.7
60	7.9	7.9	3.9	10.6	11.0	7.5	13.3	13.7	11.0	16.8	16.9	15.4
70	7.3	7.7	3.6	10.0	10.7	7.2	12.7	13.3	10.7	16.3	16.5	15.2
80	6.7	7.5	3.3	9.6	10.4	6.9	12.3	13.0	10.4	15.9	16.0	15.0

[C = shelled yellow dent corn; W = hard red spring wheat; SB = soybeans]