

Managing Stored Grain to Protect Quality (for Michigan producers)

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Grain Storage Challenges

Causes of storage challenges:

- Grain that didn't get fully dried
- Lower quality grain
- Attack mechanism:
 - Storage molds (fungi)
 - Bacteria at higher temperature and moisture

Grain Drying Basics

Drying system abilities and limitations:

- Natural air bin drying (corn in Michigan)
 - Works most years with corn up to 22%
 - Requires 1.5 cfm/bushel minimum
 - 1.5 hp/1000 bu at 15 feet deep
 - 3.5 hp/1000 bu at 20 feet deep
 - Use 2-3 cfm/bu for wetter corn
 - Get 50% more cfm/bu by using the same fan and bin filled 70% as deep
 - Relies on favorable air conditions for weeks of time

Table 1. Recommended airflow for natural-air and low-temperature wheat and barley drying.

Moisture content (% wet basis)	Minimum airflow (cfm/bu)
16	0.5
17	0.75
18	1.0

From: Wheat and Barley Drying, University of Minnesota Extension, William F. Wilcke and Kenneth J. Hellevang

Grain Drying Basics

Drying system abilities and limitations:

- Natural air bin drying (corn in Michigan)
 - Example bin 27' diameter 15 feet deep (6870 bushels)
 - At 1.5 cfm/bu and 15 feet deep
 - Requires about 10 hp
 - 10 hp will create 2 cfm/bu up to 11 feet deep
 - At 1.5 cfm/bu and 20 feet deep,
 - About 25 hp required

Corn Equilibrium Moisture Content (from MWPS-22)

T, °F	Relative Humidity, %						
	30	40	50	60	70	80	90
20	12.4	13.6	14.8	16.1	17.6	19.4	22.2
30	11.4	12.7	13.9	15.2	16.7	18.6	21.1
40	10.6	11.9	13.1	14.5	16.0	17.9	20.5
50	9.9	11.2	12.5	13.8	15.4	17.3	20.2
60	9.3	10.6	11.9	13.3	14.8	16.8	19.7
70	8.7	10.0	11.4	12.7	14.3	16.3	19.3

Grain Drying Basics

Drying system abilities and limitations:

- Heated air bin drying (no stirring)
 - Works regardless of weather
 - Requires 5-10 cfm/bushel
 - 2 hp/1000 bu at 2.5 to 4 feet deep
 - Depth is limited to limit kernel moisture difference to 5 points
 - Temperature of 120 to 180 degrees
 - 1-2 batches per day at 10 points removal

Grain Drying Basics

Drying system abilities and limitations:

- Heated air bin drying (no stirring)
 - Example bin 27' diameter
 - At 4' deep (1830 bu)
 - At least 4 hp required to get 7 cfm/bu
 - Fans vary greatly in performance (check with supplier for actual airflow)

Corn Equilibrium Moisture Content (from MWPS-22)

T, °F	Relative Humidity, %						
	30	40	50	60	70	80	90
20	12.4	13.6	14.8	16.1	17.6	19.4	22.2
30	11.4	12.7	13.9	15.2	16.7	18.6	21.1
40	10.6	11.9	13.1	14.5	16.0	17.9	20.5
50	9.9	11.2	12.5	13.8	15.4	17.3	20.2
60	9.3	10.6	11.9	13.3	14.8	16.8	19.7
70	8.7	10.0	11.4	12.7	14.3	16.3	19.3
120	3.2 @ 10% RH ← result with heated air if layer is too deep						

Grain Drying Basics

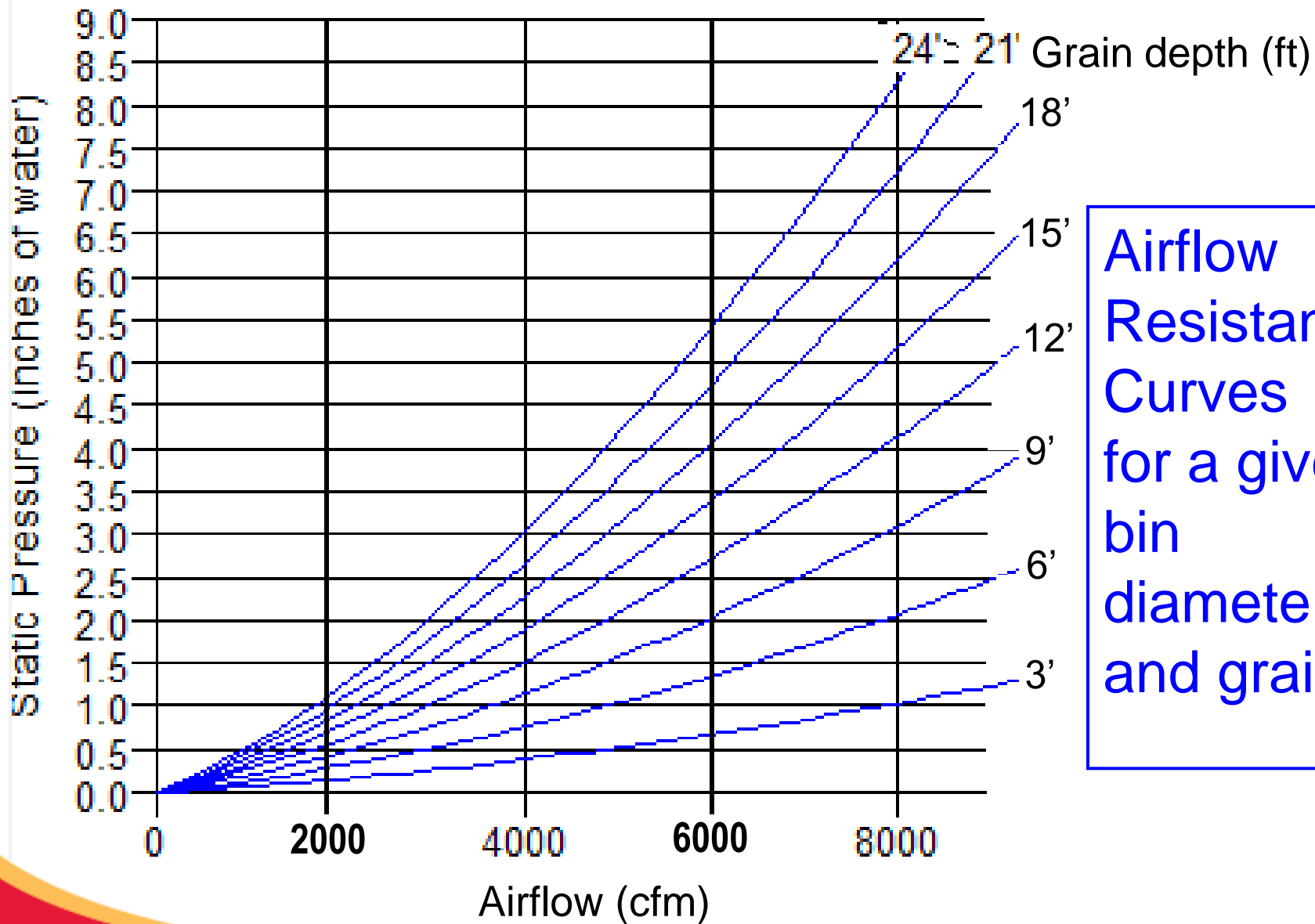
Drying system abilities and limitations:

- Heated air bin drying (with stirring)
 - Works regardless of weather
 - Requires 5 cfm/bushel
 - 5 hp/1000 bu at 6 to 9 feet deep
 - Depth is limited to maintain high airflow
 - Stirring must be adequate to move dry grain fast enough to limit over-drying
 - Temperature of 120 to 180 degrees
 - 2-3 days per batch at 10 points removal

Grain Drying Basics

Drying system abilities and limitations:

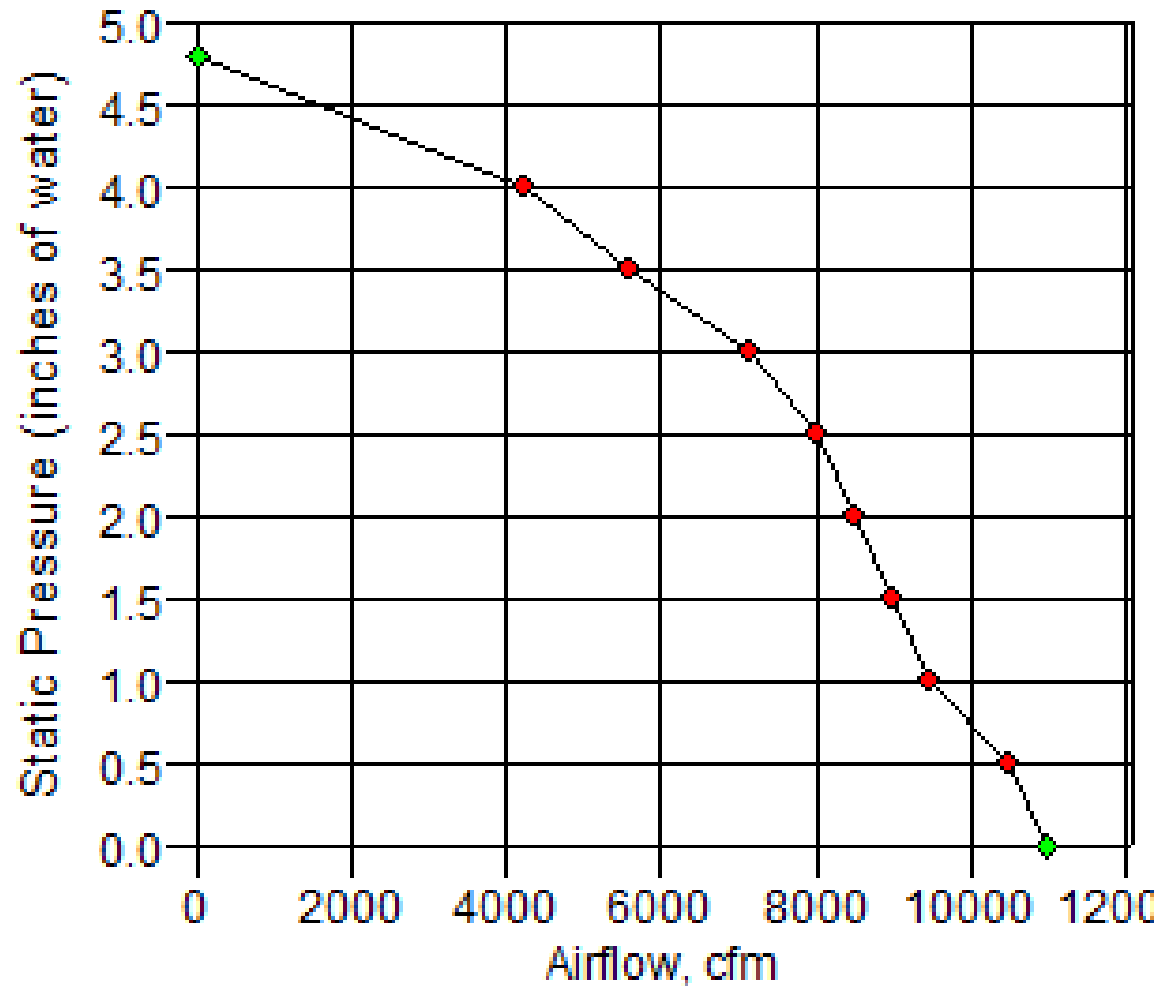
- Heated air bin drying (with stirring)
 - Example bin 27' diameter
 - At 8 feet deep (3660 bu)
 - 20 hp required to get 5 cfm/bu
 - Fans vary greatly in performance (check with supplier for actual airflow)
 - If you filled the bin to 15 feet deep, it would take more than 100 hp to get the required air



Fan performance curve

Typical Axial Fan

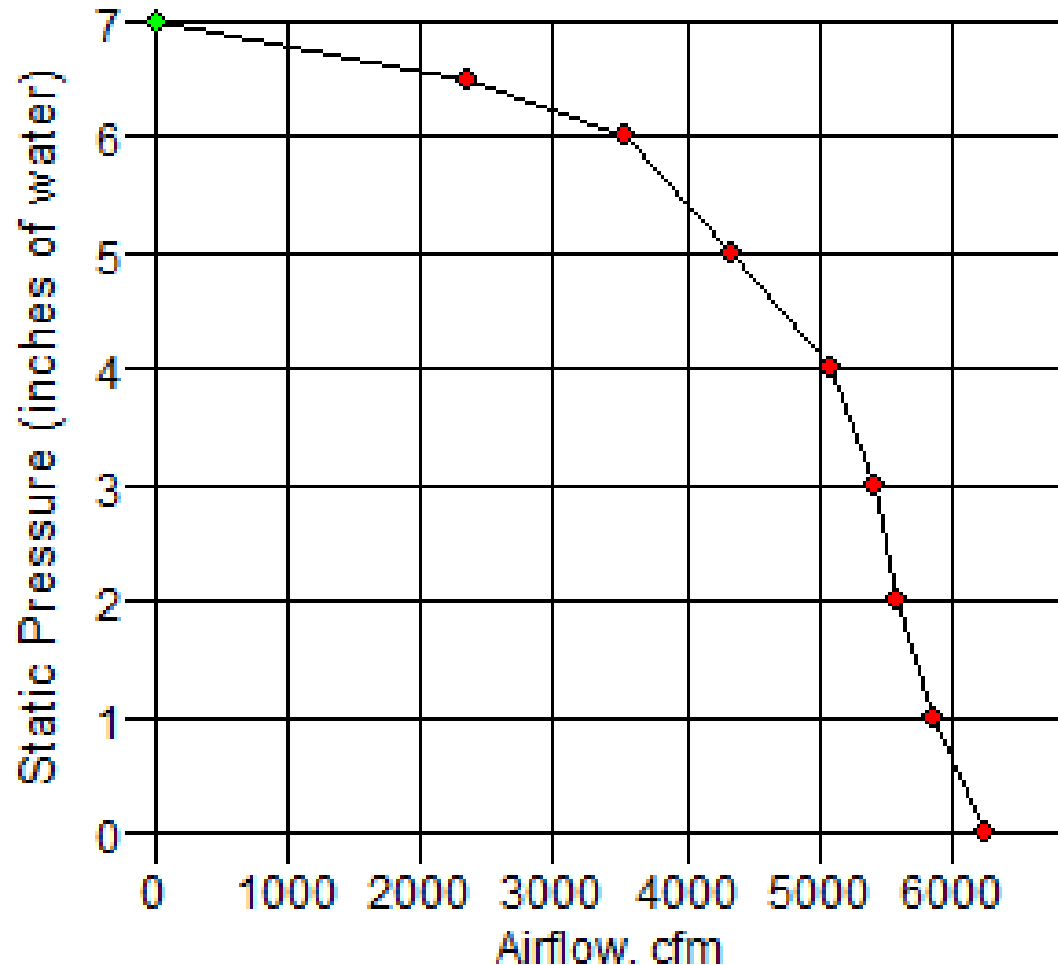
- ◆ Actual fan performance (Single fan)
- ◆ Extrapolated point(s)



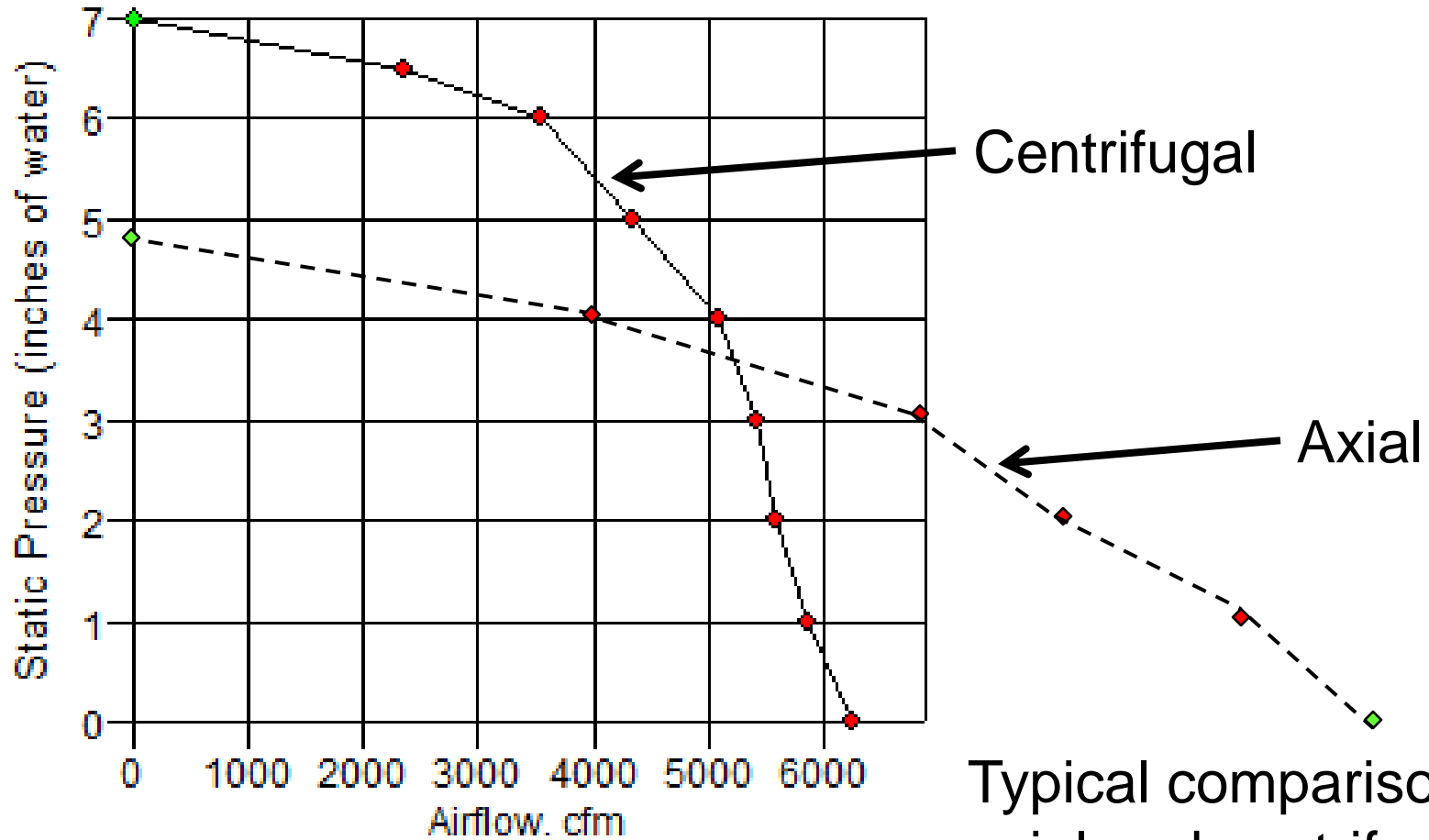
Fan performance curve

Typical Centrifugal Fan

- ◆ Actual fan performance (Single fan)
- ◆ Extrapolated point(s)



- ◆ Actual fan performance (Single fan)
- ◆ Extrapolated point(s)



Typical comparison of axial and centrifugal fans of same hp

FANS

File Edit Crop Selection Fan Selection Help

BIN AND CROP INPUTS

Selected Crop:
Corn, shelled

Floor Type: Full Duct

Bin Diameter (feet):

Grain Depth (feet):

Desired airflow (cfm/bu):

FAN SELECTION

Number of fans on bin:

Fan Arrangement: Parallel Series

Selected Fan:
7.5 hp MIDDLE STATE18-240 [Centrif.]

ESTIMATED FAN REQUIREMENTS
(to get desired airflow when bin is full)


Bin capacity (bushels): 6650


Total airflow (cfm): 8313

Estimated static pressure (inches of water): 8.76

Estimated fan power needed (hp): 19.09

RESULTS





MINNESOTA EXTENSION SERVICE

Minnesota Fans program input page

FANS

File Edit Crop Selection Fan Selection Help

BIN AND CROP INPUTS | **ESTIMATED FAN REQUIREMENTS**
(to get desired airflow when bin is full)

Selected Crop:

Corn, **Select Fan**

7.5 hp CHICAGO 13-1-106 (Centrif.)

7.5 hp CIRCLE STEEL - (Centrif.)

7.5 hp FARM FANS 724 SH | 24" (Axial)

7.5 hp KEHO 912 (Centrif.)

7.5 hp MES Example #11 (Centrif.)

7.5 hp MES Example #8 (Axial)

7.5 hp MFS 24" (Axial)

7.5 hp MIDDLE STATE MS 18-270 (Centrif.)

7.5 hp MIDDLE STATE 18-240 (Centrif.)

7.5 hp MIDDLE STATE TF 75-1 | 24" (Axial)

7.5 hp ROLFES - (Centrif.)

7.5 hp ROLFES - (Axial)

7.5 hp SUKUP 7.5-241 or 243 (Centrif.)

7.5 hp SUKUP 3500 rpm (Centrif.)

7.5-8.5 hp CHICAGO BB751F & 3F | 22" (Axial)

7.5-9.2 hp CALDWELL F24-7 | 24" (Axial)

9.3 hp AEROVENT 7-2722-DW | 27" 3450 rpm

9.5 hp MIDDLE STATE TF 95-1 | 24" (Axial)

9.5 hp MIDDLE STATE TS 95-1 | 26" (Axial)

10 hp AEROVENT CD270-10 | 27" (Centrif.)

10 hp AEROVENT 7-4261-DW | 42" (Axial)

10 hp AEROVENT 7-2498-DW | 24" 3450 rpm

10 hp AEROVENT 7-3692-DW | 36" 1725 rpm

Actual fan performance (Single fan)
 Extrapolated point(s)

Airflow (cfm)	Static Pressure (inches of water)
0	7.5
5000	6.5
6000	6.0
6500	5.0
7500	4.0
8000	3.0
8500	2.0
9000	1.0
9500	0.0

Static Pressure (inches of water)

Airflow, cfm

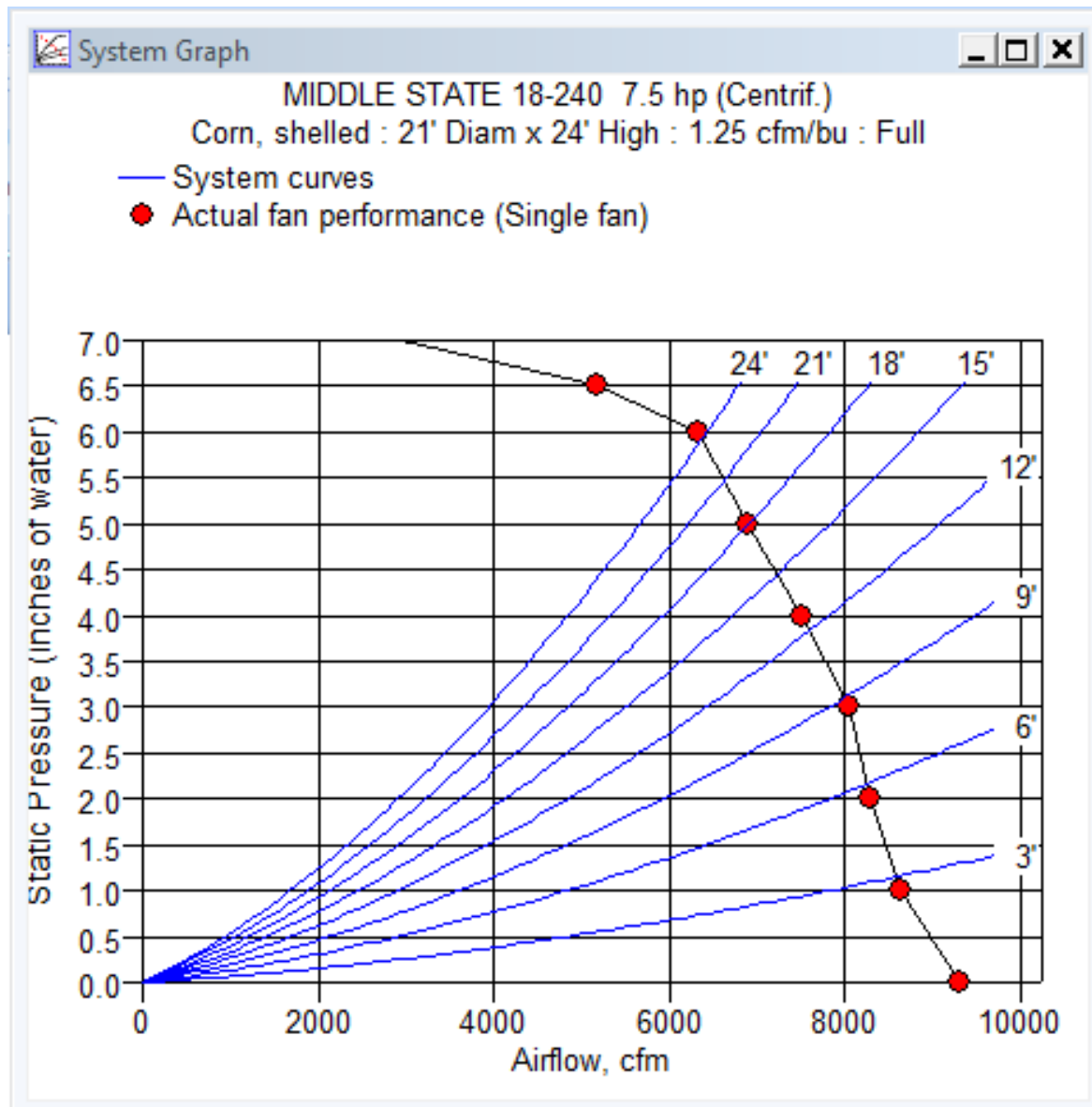
Sort By: HP Mfg.

Data

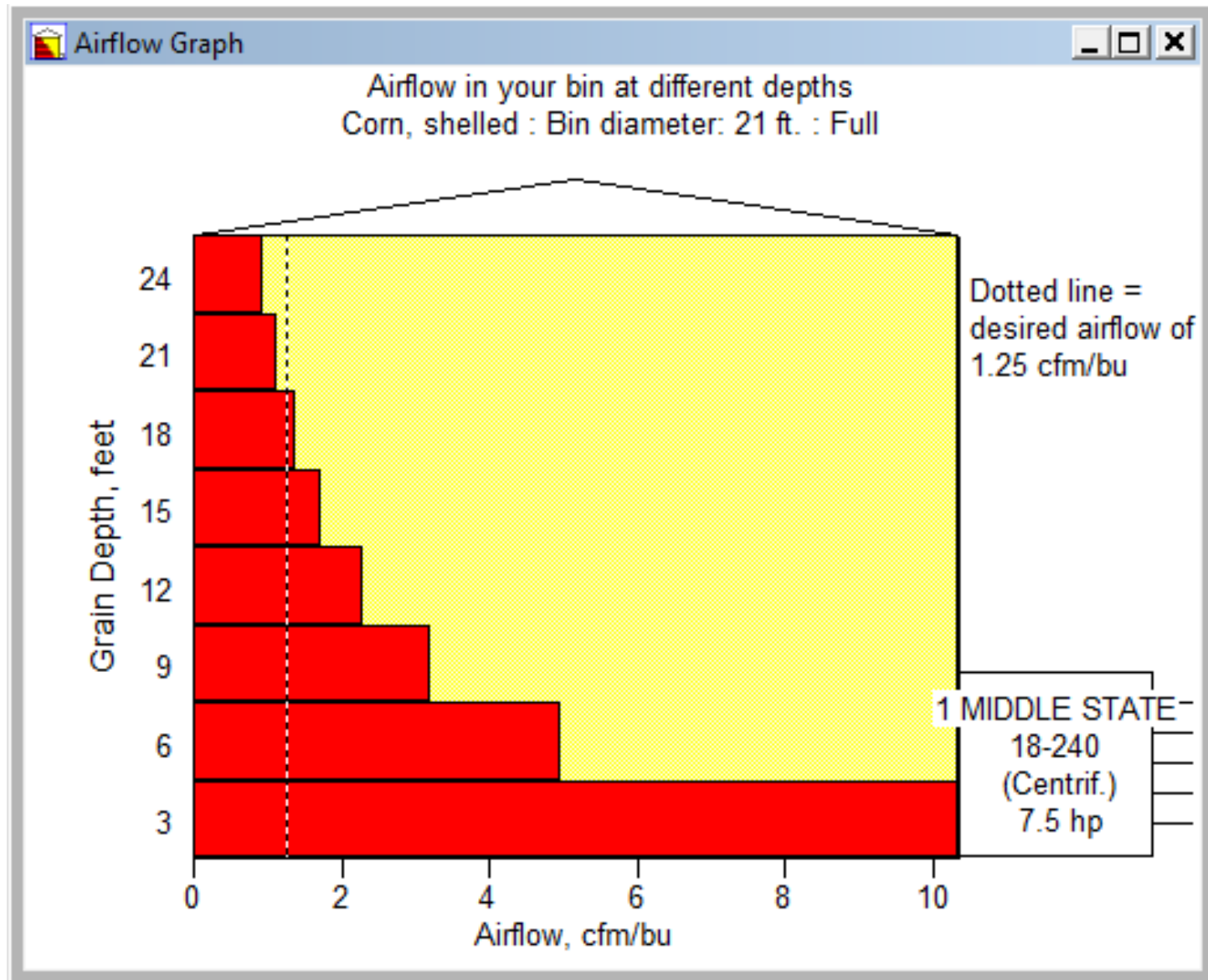
OK Cancel

Minnesota Fans program fan selection page

Minnesota Fans program system graph output



Minnesota
Fans
program
airflow
graphic
output



Airflow vs Depth Table

Crop: Corn, shelled; Bin diameter, feet: 21

Floor: Full

Airflow, cfm/bu: 1.25

Fan: 1 MIDDLE STATE 18-240 Centrif. 7.5 hp

Airflow and Pressure with Different Quantities of Grain in a Bin

Depth (ft)	Bushels	Airflow (cfm)	Airflow (cfm/bu)	S.P. (in. H ₂ O)
3.0	831	8597	10.34	1.15
6.0	1663	8258	4.97	2.17
9.0	2494	7996	3.21	3.10
12.0	3325	7594	2.28	3.83
15.0	4156	7230	1.74	4.45
18.0	4988	6905	1.38	4.99
21.0	5819	6622	1.14	5.48
24.0	6650	6368	0.96*	5.92

*Actual airflow differs from desired airflow by more than 5% at this depth. Try using a shallower depth, a different fan, or adding a fan in series.

Minnesota Fans program table output

Fans Program

University of Minnesota Extension

http://www.bbe.umn.edu/Post-Harvest_Handling_of_Crops

Post-harvest Drying Energy Use:

High temp: 0.018 gal. LP/bushel/point
range 0.010 – 0.025

Natural air: 0.33 kWh/bushel/point
range 0.30 – 0.40

energy/100 bushel/10 pts. removal

<u>System</u>	<u>gal LP</u>	<u>kWh</u>
High speed, high T, cool in the dryer	20.0	10
Batch in bin with stir	18.0	10
High T, cool in storage	17.5	8
Continuous flow bin	17.0	10
Dryeration	14.5	7
Combination Drying	8.0	70
Natural air	0.0	140

Source: National Corn Handbook, NCH-14

<u>System</u>	<u>Drying speed</u>
High speed, high T, cool in the dryer	1
Batch in bin with stir	<1
High T, cool in storage	1.35
Continuous flow bin Dryeration	1 1.6
Combination Drying	3
Natural air	4 weeks

Source: National Corn Handbook, NCH-14

Post-harvest Drying:

- Match wet storage to harvest and drying rate
- Transfer grain hot and delay cooling (Dryeration)
 - 1-2 pts additional moisture removal
 - 25% energy reduction
 - 30-60% higher dryer capacity
- Recirculate cooling and/or drying air
 - 10-30% energy reduction

Post-harvest Drying:

- Consider combination high/low temperature drying
 - 50% energy reduction
 - 300% dryer capacity increase
- Use automated moisture sensing
- Check moisture meters and equipment often

Grain Storage - Winter

What now?:

- Dry grain
- Control temperature
 - 35 degrees, cooler won't hurt or help
 - Remember to re-warm in the spring
- Check grain frequently (weekly)
 - Watch for musty odor or rising temperature
 - Smell first flush of air from the grain
 - Beware bridged or crusted grain
- Have a plan for moving grain if problems develop

Grain Storage - Winter

What now?:

- Grain at 15%-20%
 - Control temperature,
 - Check weekly,
- Finish drying or move before mid-spring
 - This grain may store OK if monitored and kept cool
 - Warmer spring temperatures will resume grain spoiling

Grain Storage - Winter

What now?:

- Grain above 20%
 - Control temperature,
 - Check weekly,
- Market or move to drying facilities this winter
 - Risk of storing this grain, even cool, is high

Future Grain Drying/Storage

Plan for adequate handling and drying
(allow for expansion)

It may not be necessary to plan for another 2009,
but know your system capabilities and have a
plan for unusual years.

Future Grain Drying/Storage

Wet holding

- Calculate daily harvest rate (bushels/day)
- Size wet holding for $\frac{1}{3}$ to $\frac{1}{2}$ day harvest capacity
- Provide good aeration (at least $\frac{1}{2}$ cfm/bu)
- Use hopper bottom tanks or dry grain hoppers

Future Grain Drying/Storage

Dump Pit

- If pit is small, conveyor speed must be high to avoid lengthy delays
- If pit is as large as largest truck/wagon, conveyor speed can be as low as hourly harvest rate

Future Grain Drying/Storage

Drying Rate

- Rate = daily harvest bu / desired hours per day
- Typically designed for 18 hours/day operation
- Grain moisture assumed from 10-year average
- This leaves you short of capacity in unusually wet years

Future Grain Drying/Storage

Drying System Type

- Depends on system size
 - Typically drying bins for small operations
 - Typically dryers for large operations
- *Guide to Planning Grain Drying, Handling and Storage Systems* gives good advice
(published in *Applied Engineering in Agriculture* Volume 16(5), page 513-525, May 2000)

Future Grain Drying/Storage

Choice of drying system depends on many factors

- Marketing options and preferences
- Availability of electrical service
- Desire for expansion opportunity
- Planning and economic return time-frame
- Grain quality and segregation desires

Future Grain Drying/Storage

A word on **test weight**

- Test weight measures density of grain
 - Pounds per volume bushel
- Test weight typically increases as grain dries
 - Kernels shrink and/or pack more densely
- Test weight may not increase for immature grain
- Test weight increase during drying is typically greater for grain dried at low temperature

Future Grain Drying/Storage

- Question: if your drying system produces higher **test weight**, do you have more weight/bushels of grain to sell?

- Answer:

- NO

- Weight (mass) of grain does **not** increase. It becomes more **dense** (same mass fits in a smaller space).

- See *Grain Test Weight Deception*

<http://www.extension.iastate.edu/Publications/PMR1005.pdf>

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