Grain Technical Information for Profitable Grain Harvesting

Air and Heat Required to Remove Moisture From Grain

Air does the work of "hauling" the water from the grain. Increasing the velocity of the air is will give us a little more speed. We can enhance the air to maximize its hauling ability by adding some heat. The heat is going to give us more hauling ability and a larger fan will give us velocity increasing the ability to dry faster. We will examine the various aspects of heat and air relationships in this article.

The Work Load

It may be interesting to know just what "work load" the air has to remove moisture. At 18% moisture you have 2.46 pounds of water to remove per bushel of wheat. That is 12,800 lbs or 1280 gallons to remove from 5000 bushels. That is equal to a pyramid of twenty- seven 45-gallon drums of water that are to be removed from 5000 bushels from 18% to 14.5% dry. How do we get this job done.

Heat and Relative Humidity

The relative humidity is the percentage of moisture that is in the air at a given temperature.

A Rule of Thumb, adapted from studies at the University of Nebraska on how increasing the ambient air temperature effects relative humidity in direct fired burners, states "that for every 20 degrees Fahrenheit (11degree C) that you increase the temperature of the ambient air you decrease the relative humidity by half". The following chart gives you the guide, for exact figures you would need to refer to the study.

Degree F	% Relative Humidity	% Relative Humidity	% Relative Humidity	% Relative Humidity
60	50	70	80	100
80	25	35	40	50
100	13	18	20	25
120	7	9	10	13
140	4	5	5	7
160	2	3	3	4
180	1	2	2	2
200	.5	1	1	1

We add heat to get dry air, which has the ability to remove water faster from the grain. Note also that the relative humidity of the ambient air has very little effect on the amount of fuel used. The cost of drying grain increases very little due to higher relative humidity. The increased fuel consumption costs arise from the rise of the air temperature. In order to dry most cereal grains you use a temperature to about 180 degrees. Costs increase when raising the air temperature from 0 degrees F than from 60F.

Note the reduction in relative humidity when adding heat. A small amount of heat may be very costly in any type of bin drying unless a bin is stirred, monitored and managed closely. See the further information on moisture equilibrium and over-drying costs.

Efficiency of Higher Heat

Iowa State University Amount of Air Needed to Remove One Pound of Water						
Air Temperature	100	120	140	160	180	200
Cubic Feet of Air	1827	1365	1090	895	750	670

Iowa State University did a study that found to remove one pound of water at 160 degrees you needed 895 CFM of air, but at 200 degrees you only needed 670 CFM. That is an increase of 34% more air needed at the lower temperature. That means the hotter you can run your dryer without grain damage the more moisture you are going to remove in a shorter period of time. The dryer will deliver a certain amount of air and it is going to be constant at a given static pressure. The capacity to dry will change with the amount of heat. The higher heat used the greater capacity and fuel efficient the dryer will be, but be aware of the possible grain damage at higher heat. Remember run your dryers to their maximum safe temperatures while being careful not to damage your grain.

Grain Damage

Studies also show that grain heat damage doesn't just come from high air temperature, but from a high-temperature exposure time relationship. Exposure time is the amount of time that your grain is subjected to heat. You've probably heard of some dryers that are damaging grain because they are run at high temperatures. One of the reasons that happens is because the dryer may hold 700 bushels, but the drying capacity of the dryer is 350 bushels per hour, you can do a calculation and figure out how long that grain is going to be subjected to heat. Some dryers that hold smaller amounts will put through grain at 8 minutes or less per point and if you take out 4 points you have about 32 minutes of heat exposure rather than two hours. It's recommend because of the differences in dryers to send in samples to test for grain damage to the Grain Commission.

Utilizing Grain Heat – Cooling in the Bin

It is often assumed and frequently promoted that one should use high airflow in order to cool the grain dumped from a dryer as quickly as possible. This is not necessarily so. It is advantageous to use a lower airflow in order to utilize the heat of the grain. Heat in the grain together with airflow decreases the relative humidity of the air moving through grain, maximizing moisture removal from the grain during the cooling process. The key is the right amount of air.

Bin cooling of grain from a dryer is an established method of fuel savings, keeping grain quality high and increasing the dryer capacity. A Rule of Thumb says, "You should be able to remove 1% of moisture for every 25 degrees F that you drop the temperature of the grain". This, however, depends on the proper fan size. The correct airflow should be approximately .3 CFM per bushel when cooling in a bin. If your fan has too high an airflow you will not get the anticipated moisture removal during the cooling process. Heat will be removed rapidly and there will not be warmth to decrease relative humidity of the air needed to remove moisture. The fan "must be small enough to do the job" rather than too big.

The same principle may apply to grain harvested slightly "tough". On a hot day grain may be coming from the field at 90 or 95 degrees Fahrenheit. When cooling this tough warm grain using a low airflow one can remove a small amount of moisture to bring the grain to dry without starting a drying front and over drying the grain. Over dried grain incurs income losses that you may get with a high airflow fan.

Moisture Equilibrium

Moisture equilibrium is the point where the air moving through grain either in the field or in a bin can no longer remove moisture from the grain. Moisture equilibrium varies with relative humidity and temperature. Understanding moisture equilibrium allows you to make harvesting and drying decisions.

In wet falls there are often weeks when harvesting dry is not possible and natural air-drying does not get the grain dry. If the moisture content of the grain in the fields doesn't come down it's not going to dry in the bin either.

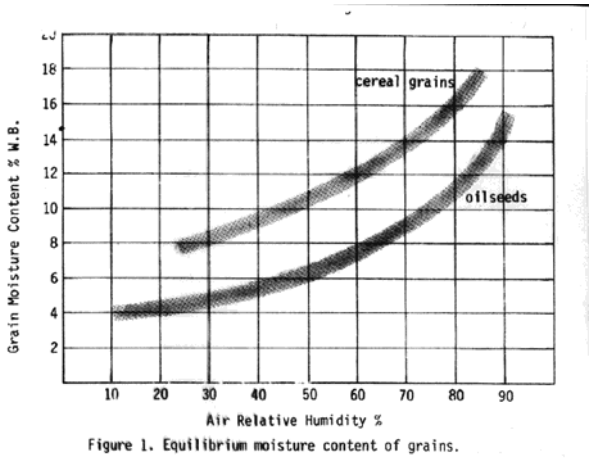

Figure 1. Equilibrium moisture content of grains.

This chart is from Saskatchewan Agriculture. If, for example, we have 65% relative humidity it would be about 14. If the relative humidity was down around 50 or 60% we could get our grain down to 12. This is why on a nice day when you are combining, it may start out as 14, but as the day progresses the grain will become drier and drier and if the humidity is around 40 or 50% it will over-dry considerably, but if it stays around 65% you will take it off just right and it is going to be fairly constant. On the other hand if you had a year when the relative humidity is down to about 30 or 40% and that takes the grain down to possibly under 10. That drying ability of air has to do with relative humidity and the ambient temperature.
In a high relative humidity fall it is not possible to dry grain with natural air only and if the relative humidity is low or artificially reduced there can be severe over-drying costs. See Following Chart. Take the basic over-drying cost of 5000 bushels wheat at $5.00 per bu., standard moisture of 14.5% at various moisture percentages.

******* Over drying Costs *******

Std. Wt. Per Bushel	**60**	:	Base Commodity Price			**5.00**
Std. % Moisture	**14.5**	:	Bushels in Bin			**5000**
==========CALC # 1==========						
Value of Grain / Bu	5.00					
Grain Over dried To %	14.0	13.5	13.0	12.5	12.0	11.5
RH % Approx					60%	
Lost Income / Bushel $	0.029	0.058	0.086	0.114	0.142	0.169
Lost Income / Bin $	145.00	290.00	430.00	570.00	710.00	845.00
----------continuation----------						
Grain Over dried To %	11.0	10.5	10.0	9.5	9.0	8.5
RH % Approx	50%		40%		30%	
Lost Income / Bushel $	0.197	0.223	0.250	0.276	0.302	0.328
Lost Income / Bin $	985.00	1115.00	1250.00	1380.00	1510.00	1640.00

Note at 13%, the over-drying cost is 8.6 cents a bushel or $430.00. At 11% is $985.00, 10% is $1250.00, and 9% is $1510.00 for 5000 bushels. There is a significant cost at lower Relative Humidity. At the lower moistures the field losses also increase adding to the lost income.
The over-drying costs are really quite high whether in the field or in the bin. Handi-Facts Agdex 736.1 and the newer Natural Air Grain Drying published by Saskatchewan Agriculture Family Farm Improvement Branch deal with this concept in more detail

Safe Moisture Content

The moderately high moisture content in grain is usually safe as long as the ambient air temperature is low and you have some air moving through the grain. There are charts on safe storage times a most Agricultural Extension offices.

Grain Drying Operating Costs

A Grain Dryer should be convenient so that grain drying can take place at the time of harvest. The combine and dryer should start at the same time.
Based on an average drying temperature of 180 degrees, 18% moisture content grain, which will vary. If we had 65F degree weather, we project less than 10 cents a bushel for propane costs, natural gas would be considerably less, if you have a high air-flow dryer it may be a little higher, or a low air-flow dryer may be a little lower, but somewhere in that ballpark. There is a considerable savings in fuel costs when discharging grain hot from a dryer. Grain threshed at 18% moisture with a target of 14-14.5% there would be a savings of about 25%. The grain is discharged at about 15.5% and about 100F when cooled slowly in the bin there will be about 1% of moisture removed, emphasis is on slowly.
Unfortunately, a lot of people, when they are drying grain, dry grain when the weather is cold, especially if you are getting custom work done. Remember the colder the weather the higher the cost.

Airflows for various applications.

Airflow depends upon the process and upon the crop.
Aeration we are looking at a very low airflow. What we are doing is we are setting up something that can run for a week at a time to get the temperature of the grain down. Very little air is required, about 1/10 of a CFM a bushel is probably about right.
Tough grain before drying takes more airflow approx.0.2 CFM a bu. A small ¾ HP fan will do wonders on a 5000 bu. bin for this purpose.
Cooling in the bin wheat, barley a low airflow is sufficient. Hot corn requires about .3 CFM per bu. The bin should be full or at least a sufficient amount of grain to restrict the airflow to specified amounts. In many bins a 1 – 3 HP fan is ample for these applications.
Note small fan sizes are often not stocked because you can't make a living selling 3/4HP fans.
Natural air-drying target should be about 1 CFM per bu. if possible.

The direction of the air doesn't make a great deal of difference in a lot of applications, but it does in some others. An upward flow or push airflow has the advantage of the farmer being able to check out how the grain is being cooled off, or to test the air physically by reaching into the bin if it's natural air drying or cooling in a bin. For a bin that is sealed tightly around the eaves it is best to pull or suck the air if you possibly can otherwise a lot of moisture may accumulate on the bin walls particularly in the late fall. The condensation of water will cause it to run back into the bin. At 15.5% to 14.5% there is .71lbs per bu or 351 gallons of water to remove.
Note cooling just behind the dryer has its risks when using only one hopper bin. The first grain coming from the hopper bin is usually the last grain from the dryer and may not be completely cooled. Grain will need to be dried longer in the dryer increasing fuel costs If one waits till the grain is cooled it may cause a bottleneck around the dryer.

High Temperature Grain Dryers

A Grain Dryer should be convenient, if not, it is not going to be used in a profitable way. The are a number of ideas and attitudes about grain dryers.

1) I don't want any thing to do with them and I don't need them. Dryers are not needed in my area of the country.

2) I want a grain dryer but if I get one it's got to be a big one and I can't afford it. I can take my grain to someone and get it dried. This person seldom gets the benefit of profitably

drying grain. It's usually a cost either in high custom costs, winter trucking, or reduced commodity prices.

3) The next person knows the benefit of combing and drying at the same time. That person will probably have a dryer that is just big enough to dry one days' combing over a 24-hour period. Dryers of this size and type have less capital investment and are generally convenient and automatically controlled. This type of dryer will dry grain with a minimum of start-up time and supervision. Generally such a person understands the benefit of starting early as possible not only in the season but also daily. There is an understanding that to start combing at about 18% will reduce field losses. These reduced losses will more than offset the cost of the fuel required to dry the grain. The operators also avoid combing over dried grain with its accompanying field losses.