MONITORING THE USE OF WATER ON GRAIN

The issue of adding water to grain is much broader than just its effectiveness in controlling dust or preventing dust explosions. One of the primary concerns voiced during the hearings on prohibiting the addition of water was the fact that it could be used to increase the weight and deceive the buyer, particularly in the international export market. The FDA prohibition on the use of water specifically referred to use of water for the purpose of increasing its weight or to make it falsely appear to be of greater value than it actually is. [Food and Drug Administration, 1979]. It is important to evaluate the validity of these concerns and the feasibility of monitoring the industry to prevent the use of water to falsify weights and moisture meter readings.

The appearance of greater value would be possible only if the moisture meter is biased downward on rewetted grain or if the water is incorporated without the buyer measuring the moisture content. Since nearly all grain is sold on the basis of weight and a moisture meter reading at origin and/or destination, the deception could not be the result of failure to measure. The only source of deception would be an incorrect measurement of moisture. Most research shows that the meter reading is temporarily biased upward during a period of water absorption. However, the dielectric response returns to normal within a few hours, depending on temperature, environmental humidity, and average moisture content. "At low grain temperatures and/or when larger amounts of water are added, longer waiting periods are required before indicated moisture content approaches true moisture content. Warm wheat absorbing 2 percentage points may require less than 1 hour, while wheat with temperatures near freezing absorbing several percentage points may require as much as 24 hours" [Bloome et al., 1982].

The primary incentive for adding water derives from a market pricing system where the price and quantity have not been adjusted to accurately reflect the differences in dry matter contained in grain at different moisture contents. Grain at moisture levels below the base (15.0% in the case of corn, 13.0 % in the case of soybeans, 13.0 or 13.5% in the case of wheat) provides the opportunity for economic gain by adding water. If the price per ton or bushel is the same for 14% moisture corn as it is for 15% moisture corn, and no adjustment is made for the dry matter per ton, there is a strong incentive to add moisture to bring the 14% corn up to 15%. The market is offering to pay corn prices for water.

However, if the water is added after the grain has been weighed, there is no impact on the contract weight which is the basis for payment. If the water is added before final weighing, the sample measurements will still indicate to the buyer the actual quantity of dry matter or the equivalent weight at contract price. With accurate information about quantity and moisture content the buyer cannot be "deceived". If the moisture content exceeds the contract moisture, the grain would normally receive a discount, or be certificated as failing to meet the contract, or FGIS would require that that sublot be unloaded.

It is important to establish the source of the concern of the foreign buyer. Water cannot be added without being reflected in the moisture reading or the weight or both. An increase in the moisture content would also violate the contract, unless the moisture content of the grain is below the contract moisture. Moisture content of grain is often below the maximum limit specified in the contract. Under this condition, the complaint that the buyer has been deceived or cheated must be based on an expectation by the buyer of receiving better quality than was requested, e.g. receiving 14% moisture (86% dry matter) corn at the price negotiated for corn with 15% moisture (85% dry matter). It is unclear in this example whether the buyer or the seller has been disadvantaged.

The use of water to suppress dust in grain elevators is a technology that could provide a low cost method of reducing dust emissions to comply with air pollution regulations and prevent dust explosions. If properly done the impact on grain quality will be minimal, the weight of the water will be included in the weight of the grain on the scales and the moisture determination will correctly identify the percent of that weight which was water and that weight which was dry matter.

In the Congressional Hearings the difference between the house and the senate versions of proposed legislative controls was the belief that the application of water could be monitored by FGIS and those elevators improperly applying water could be identified and prosecuted. The OIG maintained that there will always be a way to bypass the monitoring system, while some researchers and some members of the grain industry claimed that a system could be developed that would be foolproof.

The pros and cons of the enforcement of a rule promulgated by FGIS that would allow for a total application rate of 0.3% of water for the purpose of preventing dust explosions or complying with air pollution regulations are as follows:

(1) A permit system can be established whereby advance approval by FGIS must be obtained prior to installing a water application system. The permit would have sufficient engineering description of the application system such that an FGIS engineer could insure that the system would function to either prevent dust explosions or assist in complying with air pollution regulations. Reporting requirements could be included to insure that the system was not being used to manipulate the marketing system prior to approving installation. Enforcement of violations could be included for those facilities who had exceeded allowed moisture additions based upon entering and exiting grain moisture contents. This concept is similar to the permitting and enforcement rules associated with regulating air pollution in most states. For example, more than 25,000 facilities have permits and are subject to enforcement in Texas.

PROS: A system of using water to make elevators safer would be available.

CONS:

(a) FGIS would have to hire more staff to handle the permitting and enforcement functions. Most of the additional permitting staff would have to be qualified engineers. FGIS suggested that they would have to place an employee in every elevator to insure compliance. FGIS has estimated that the cost of the permitting system would exceed $1.5 million/year.

(b) The cost of a water application system for an elevator would be increased by the licensing requirement in that it would have to include the engineering specifications associated with approval of their permit application.

(c) The elevator would be required to submit reports to FGIS that would potentially subject them to fines and penalties.

(d) FGIS has not operated with a permit/enforcement system. This will be a new system for a regulatory agency and it would take time to implement.

(e) FGIS has had limited regulatory authority over country and inland terminal elevators in the past. This system would bring country elevators applying water application systems (through a permitting process) under the authority of FGIS which may not be popular.

(f) A system of fines and penalties will be required for those facilities who attempt to abuse the system.

(g) Overseas customers may claim that the quality of U.S. grain is reduced because we are allowing the application of water to grain.

(h) FGIS would still need to prove the source and intent of any increased moisture content.

(2) Some have suggested that the marketing system has an inherent safeguard against abuse. If an elevator were to add water using a fire hose, the grain quality would rapidly deteriorate. Hence, as the grain progresses through the country elevator to the inland terminal to the export, this high moisture grain would be detected and the abuser identified. This concept recognizes that grain must be kept below specific moisture contents in order to prevent quality deterioration: 14% wb for field grains and 11% wb for oilseeds.

PROS:

(a) The bureaucracy associated with a permitting system operated by FGIS would not be needed.

(b) The use of water for dust suppression would be less expensive.

(c) The marketing ability of abusers would be impacted by inland terminals and export facilities not purchasing grain from this location.

CONS:

(a) There would be allegations of wide spread abuse (adding water for economic gain).

(b) There would be an incentive to add water to low moisture grain beyond the proposed 0.3% level.

(c) If an abuser is identified, proof of intent would be required and may be difficult.

(d) If the perception that a grain elevator's competitors are abusing the system by adding water, there will be an incentive to abuse the system to meet the competition.

(3) Some have proposed a computer controlled water application system that would allow for monitoring to prevent abuse. This system would prevent the over-application of water to grain. One commercial vender offers such a system.

PROS:

(a) This method would allow for the use of water without the cumbersome bureaucracy of FGIS implementing a permit system. It would, however, require FGIS grant approval to the elevator prior to installation.

(b) The engineering associated with such a system would have to be a quality process eliminating the simple systems that could be used to easily abuse the application of water to grain.

(c) FGIS could control the number of elevators adding water to grain by only approving systems that had been approved in advance.

(d) Only systems that had been thoroughly reviewed by FGIS would be approved.

CONS:

(a) Irrespective of the engineering safeguards, any system can be circumvented if the operator of the system wants to abuse the addition of water to grain. Hence, enforcement would require periodic checks to see if the grain elevator operator is complying with the imposed application limit. Fines and penalties will have to be developed for those facilities who purposely or inadvertently add too much water to grain.

(b) No regulator agency should be in the position of recommending a vendor. There will be the potential of approving a system that is supplied by a single vendor.

(c) The monitoring process would have to be developed to insure that the system is working properly. One control strategy is to monitor and report the total water used. An alternative system would require the elevator to report moisture contents of all incoming and exiting grain and require that no grain leave the facility with moisture contents higher than the safe storage moisture content of that grain.

<u>Summary of Monitoring Strategies for the Use Water for Dust Control</u>

The use of a rule/permit enforcement system to monitor the application of water to grain is technically feasible. A similar system is currently being used by air and water quality regulatory agencies. However, it would require an expanded role of FGIS and require a significant increase in resources for the agency. In this time of reduced federal funding, the resources may not be available.

The concept of using the marketing system as a self regulatory process and limiting the water application rate (by rule) to no more than 0.3% by weight has merit. It may be possible to include in the rule-making that any grain leaving an elevator that is using water for dust suppression will be given a limit on the moisture content of grain to be marketed. This system would allow for regulating grain quality without having to prove intent. If an elevator using water, allowed grain to leave the elevator with a moisture content in excess of that allowed by rule, penalties would be levied irrespective of the source of moisture. This strategy would be difficult to apply at facilities other than export. Processors and country elevators often receive or ship grain at moisture levels too high for safe storage. Limits on moisture content at any point in the market channel will restrict the free operation of the market to choose quality based on price and value.

The proposal to allow the use of computer controlled equipment to insure that no more than 0.3% water is applied to grain would be difficult to implement without recommending a vendor. In addition, equipment can fail and an inadvertent application of water to grain could occur. A combination of equipment and some form of regulation on maximum moisture content could be implemented.

The FDA regulation and the 1987 ruling by FGIS requires that regulators determine if the moisture content of the grain has been changed in a manner that violates the law. Enforcement is extremely difficult because prosecution of violations must prove motive. In some situations the violations are obvious and the intent to defraud is readily established. FGIS investigators reported several instances of clear violations. "Our task force discovered the use of fire hoses to apply a steady stream of water to grain on conveyor belts, elevator legs, and in elevator spoutings." At one facility "the water pipes were in a false grain chute, entirely there for concealment purposes. ... We also repeatedly found dust suppression systems misused. Application points at the critical dust control points such as the bottom of a truck dump before the grain is elevated into the house, the nozzles were nonfunctional and the pressure was disconnected and the pipe was not even inserted into the system". Other examples are available [Stang, 1993]. Another example of the difficulty of proving intent is provided by a case in Nebraska, where in August, 1992, the USDA inspector general and Nebraska authorities raided a grain company and found a hose rigged to pure water onto a belt carrying grain. However, the chief operating officer testified he was adding water to control dust, and a federal grand jury in Omaha did not indict the company for economic adulteration because intent could not be proved. [The Wall St. Journal, 1993]

Motive and intent is even more difficult to establish from data on changes in moisture content. FGIS investigators reported the results of monitoring inbound and outbound moisture levels of grain at a country elevator for a period of three months. The moisture content of the grain received during the three-month period averaged 13.5%. The average moisture of grain in outbound railcars was 14.5% to 15.0%. The 1 to 1.5 percentage point increase could have been the result of water added by the elevator. However, there are numerous other equally plausible explanations which would not have been illegal under either FDA or FGIS regulations. Possible explanations include: (1) aeration to control temperature and insects, (2) blending 16% moisture grain with low moisture inbound grain, (3) the cars loaded out may have been selected from higher moisture bins and grain with below average moisture was still in storage, and (4) differences in the bias of different moisture meters (some elevators use state-approved meters on inbound grain and the official FGIS meter on outbound grain).

There are other causes of increased moisture content in grain. Handling cold grain from northern origins in the warm, high humidity conditions found at the gulf ports, will result in an increase in moisture through absorption or through condensation on the surface of the kernels. In an environment of 50 F and 40% RH corn has an equilibrium moisture content (EMC) of 11.2%. In an environment of 60 F and 65% RH the EMC is 14.8%. In an environment of 80 F and 90% RH the EMC is up to 19.1%. Grain must be exposed to this environment for an extended period of time to reach this equilibrium. The rate of moisture absorption will depend on aeration airflow and the temperature of the air. Air at 80° F would be expected to transfer moisture much faster than air at 50° F. An airflow rate of 1 cfm/bu will change temperature 2 times faster than an airflow of 0.05 cfm/bu. While the equilibrium moisture data illustrate a potential for a significant change in moisture content during transfer from a midwest elevator to a gulf port elevator or through aeration, it could take 120 to 240 hours of aeration to achieve that magnitude of a change in moisture contents, using airflow rates of 0.1 to 0.05 cfm/bu, respectively.

Other reports have demonstrated that increases in moisture content of grain frequently occur during transfer between two points in the market channel. Wade and Christensen [1977] reported, "Corn weight increased 0.1 to 0.5 percent from condensation during aerating with ambient air. Similar conditions occur at southern U.S. terminals which may cause gains over 0.1 percent as grain is exposed during handling." [Wade and Christensen, 1977].

More than one heat and mass transfer mechanism is at work in the absorption process. Movement of moisture between air and grain is driven by differentials in vapor pressure. Equilibrium is achieved when the vapor pressure within the grain kernel is in equilibrium with the vapor pressure of the air. If grain is exposed to air with a particular vapor pressure for a long enough period, it will come to its equilibrium moisture content, either by gaining or losing moisture.

When grain temperature is below the dew point of the air, moisture will condense on the grain just as it does on the surface of a glass of ice water. The condensate is then absorbed into the grain. Anyone who has watched cold or frozen grain being unloaded from a barge in a Gulf port will testify that this is dramatic. As the water vapor changes state it releases heat that warms the grain. The process will continue until grain temperature exceeds the dew point of the air. However, it is limited by the amount of air that contacts the grain during high capacity grain movement.

When grain is cooled by aeration, moisture is removed. When grain is warmed by aeration, moisture is restored to the grain. Foster [1967] alternately cooled and warmed wheat samples between 50 and 80° F by aeration. Moisture reduction during cooling averaged 0.47 percent while moisture increase during warming averaged 0.58 percent. These moisture changes occur rapidly, with the passage of the cooling or warming front, and are, in normal temperature, humidity, and moisture content ranges, independent of the relative vapor pressures of the air and grain. After aeration cooling or warming has been completed, any further moisture transfer will be driven by the differential in vapor pressure.

Moisture transfer due to vapor pressure differential is much slower than moisture transfer due to temperature differential. Raising the moisture content of grain by aeration with moist air requires days and weeks and will normally not pay the power cost of aeration except in shallow grain depths. In contrast, warming grain by aeration requires less time and the returns in increased sale weight can be 10 to 20 times the cost of aerating.

The moisture content of grain may be altered in many ways and for many different reasons.

1. Direct application of water through spraying, fogging or misting.

2. Aeration of grain when the ambient air has a relative humidity content above the equilibrium relative humidity of the grain being aerated. The rate of absorption of moisture during aeration depends on several factors including air and grain temperature, air flow, genetic make-up of the grain, and previous drying and storage history.

3. Blending dry grain with grain of higher moisture. This is an essential management practice at all elevators, including dumping grain from any two trucks into the same bin, unless both trucks contain grain with identical moisture contents. Grain of different moisture contents will equilibrate in a relatively short period of time when uniformly blended. The equilibration process results in moisture from the wet kernels moving to the dry kernels [Hill and Wei, 1993].

4. Loading grain during periods of high humidity, including during a rain storm. Moisture absorption from humid air is relatively small if the grain is exposed to the humid air for only a short period during loading or belt transfer.

5. Selecting the time of day for harvesting. Grains (especially soybeans) change moisture rapidly as temperature and humidity change in the field. It is not unusual for soybeans to gain 1 or 2 percentage points of moisture from high humidity air during the night, and then lose that moisture the following day. Farmers can "add" moisture to soybeans by choosing to harvest in the early morning hours instead of late afternoon. The end product of this process cannot be distinguished from a similar result using aeration.

6. Seasonal changes while the grain is in the field. Changing weather conditions result in an increase and decrease in moisture content of grain many times between maturity and harvest. The drying process from physiological maturity to harvest moisture is not uniform.

None of the changes in moisture content described above are illegal, unless the motive is to "increase its bulk or weight, or reduce its quality or strength, or make it appear better or of greater quality than it is". [Food and Drug Administration, 1979]. However, FDA continued to assert that any method for increasing moisture was illegal if the motive was to increase the weight or value of the grain. "We hold this position regardless of how the water was added and regardless of who adds it. Aeration of wheat during humid periods for the purpose of increasing its bulk or weight in order to maximize profits is not acceptable and is illegal for reasons outlined above" [Hile, 1981].

The use of aeration presents a particularly ambiguous situation for enforcing a prohibition. Multiple motives are usually involved.

Sentry Technologies (Chanhassen, MN) has developed an aeration controller which is designed to operate fans on grain storage bins to minimize temperature differences between stored grain and the outside air. By minimizing temperature differences, it is possible to prevent moisture migration which otherwise leads to spoilage in storage. The controller also measures outside air relative humidities. Since grain is a hygroscopic material, it will reach a moisture content that is in equilibrium with the temperature and relative humidity surrounding the kernels of grain. The aeration controller is programmed with equilibrium moisture contents for 20 grains, including corn, soybeans, wheat and sorghum. The operator selects the desired bin moisture content, then the type of grain, and the airflow per bushel provided by the aeration fan. Every 15 minutes, the controller calculates a 21-day moving average outside air temperature which is set as the target temperature for the grain. Then, if the present temperature will move the grain temperature closer to the target temperature <u>and</u> if the present relative humidity and temperature conditions create an equilibrium moisture content that is near the center band of the desired moisture content, the fans will be turned on. Every 15 minutes for 24 hours per day the decision to turn fans on or off is re-evaluated by the controller. Farmers are using aeration to increase moisture content of grain and FDA is not taking legal action [Stout, 1995].

The target moisture is applicable whether the moisture content is above the base or below the base moisture set by the market. In the rewetting mode fans operate when outside air conditions create an equilibrium moisture that is higher than the center band of the desired bin moisture content. In the drying mode, fans operate when outside air conditions create an equilibrium moisture that is lower than the center band of the desired bin moisture content. [Sentry Technologies, 1994]. One of the other cited advantages of this system is that insects like "stale" air. With fans starting at frequent intervals, there is less opportunity for "stale" stagnant air which helps to reduce insect activity. Thus, good management strategies for managing stored grain may inadvertently increase the moisture content of overdried grain. The effect from the point of view of the buyer, is the same as a deliberate attempt by the seller to increase the weight by adding moisture. Even without the sophisticated controls, aeration of grain in storage is recommended. If the fans are run continuously, the moisture may be increased and decreased several times during a storage season.

The incentives for adding water to grain come primarily from the opportunity to return over dried grain back to the base moisture set by the market. Dust control may be less important than the economic incentive of increased weight, especially at the farm and local elevator. FGIS permission to use additives for dust control tied legality to motive and generated the potential for marketing firms to abuse the intent of the regulation. That abuse was the primary justification for Congressional Hearings and the eventual action by FGIS to prohibit the use of water regardless of intent.

Enforcement of the prohibition by FGIS and FDA has been difficult. FDA's stated policy was that "We will consider regulatory action in those cases where there is evidence of consumer deception or of a safety problem arising from the addition of moisture to grain" [Hile, 1985].

Only one instance of an attempt to enforce the FDA ruling has been found. In 1983 a farmer in Kent County, Michigan was accused of delivering corn that had been rewetted to the Commodity Credit Corporation. The warehouse which accepted the corn notified the Michigan State Police, who in turn notified the FBI. The Office of the Inspector General was then alerted. Records do not show any final action and OIG does not record any subsequent prosecution. [Michigan Farm Facts, 1983.] Officials in FDA have no records or memory of any investigations or prosecutions related to the prohibition of adding water to grain, based on the FDA regulation. [Perrett, 1995] In fact, in 1987, 5 elevators in the State of Washington were found to be adding water to grain being loaded on barges. The rate of water varied at three of the sites from 8 to 12 gallons a minute, while the other elevators estimated they added from 500 up to 5,000 gallons of water per bargelot. These findings were referred to FDA. "FDA advised us that this matter has come up several times over the past decade and they recently discussed it with headquarters. They believe that it is a definite violation if water is added to grain to increase bulk or weight. However, if water is being added for dust control, they do not believe that prosecution is feasible. FDA has not set limits for the amounts of water that can be added to grain for dust control. Since each of the elevators visited claimed that they were adding water to control dust, and since any other elevators we visit would probably make the same claim, we recommend that this case be closed" [Joyce, 1988].

Many farmers and country elevators continued to use water as a means of bringing grain back to the desired moisture content. Base moisture received a premium, either in the quantity purchased or the absence of discounts. The market incentives strongly favored grain at the base moisture and the market rewarded those who achieved that base moisture. Blending of wet and dry grain was inevitable and it was impossible to differentiate between blending for the convenience of handling (e. g. unloading two trucks into the same bin) and blending for the purpose of increasing the moisture content of the dry grain. As indicated earlier, blending wet and dry kernels results in moisture moving from the wet kernel into the interstitial air and from there being absorbed by the dry kernels. The process is the same as aerating with high moisture air.