Donahaye, E.J., Navarro, S. and Leesch J.G. [Eds.] (2001) Proc. Int. Conf. Controlled Atmosphere and Fumigation in Stored Products, Fresno, CA. 29 Oct. - 3 Nov. 2000, Executive Printing Services, Clovis, CA, U.S.A. pp. 567-470

FUTURE BULK GRAIN BIN DESIGN NEEDS RELATED TO SEALING FOR OPTIMUM PEST MANAGEMENT: A MANUFACTURER'S VIEWPOINT

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ABSTRACT

Metal grain bins for storage at farm and commercial facilities are normally not constructed to be airtight. They were designed to allow for the aeration system to remove heat buildup and moisture *via* the air space between the roof and sidewall. Making most joints airtight was also not a consideration since the objective was to keep moisture out. The overlap of the metal sheets took care of this. However the desire to find alternatives to enable reduction in the amount of fumigant used to control insect infestation is forcing manufactures to look at other methods of sealing bins. Small-scale corrugated grain bins have been adequately sealed at Purdue and Oklahoma State for use in research. Actual full-scale corrugated bins have also been adequately sealed in Pistachio storage facilities in California. The challenge to accomplish this in normal grain facilities is to convince the user of the need to spend the extra money and to convince and train the commercial bin erectors in the proper method. Special vents must also be designed to keep the fumigators from having to manually seal the vents. Other means for aeration may have to be developed in sealed bins to eliminate moisture condensation on the underside of the roof and to eliminate the possibility of creating excess pressure on the roof that could cause partial structural failure.

THE PREMISE

For many years the focus on grain bin design was to enable storage of grain in bulk by a method that would maintain grain quality during storage. One of the best technologies in this respect was aeration. The practice of leaving the roof connection at the sidewall open and adding vents at strategic locations around the roof has long been the norm. For many years it was thought that the best method of aerating was by employing a suction system, which demanded a sufficient opening for air entrance to ensure that a vacuum would not cause a structural roof failure. In recent years there has been a trend to reverse the aeration procedure and pressure systems are now the norm. Large amounts of air are introduced into the grain mass *via* the aeration system to equalize temperatures and an adequate opening must be provided at the top of the bin to prevent the danger of up-pressure roof damage. There was also little concern over small air leaks around the horizontal seams as the overlap of the sheets prevented moisture from getting into the grain mass.

As we begin to adopt the concept of sealed storage with the objective of reducing the amount of fumigant or controlled atmosphere (CA) required to kill insects infesting the grain mass, so, grain bin manufactures and installers will have to rethink their designs and construction methods. As with any product development project, the long-term objective is to achieve minimum feasible cost of the installed structure.

We now have to review what will be required to make these structures airtight, and we shall have to change our attitude with respect to the lowest cost image. This is not to say that competition will not still create a competitive scenario, but the lowest costs for sealed storage will be higher than what end-users are accustomed to.

For many years the industrial bulk storage market has demanded much the same type of structure as what may prove to be the way the grain industry is moving for sealed storage. Bulk storage must be essentially airtight as introduction of outside air into the stored-product may result in sweating, dust emissions and other factors that involve high dollar-loss of product, or create environmental concerns. In order to meet the demands of this industry, bin manufacturers have had to look at different materials to seal all joints. Methods of venting have also been modified but not because of aeration requirements. Traditionally these silos are filled by pneumatic means, so vent relief is required to prevent structural roof damage as well as dust emissions during the filling process.

Grain bins have been constructed that meet the minimal requirements for CAF conditions at both the research level and for some specialty products. Both Purdue University and Oklahoma State University have a number of small bins built for research that employed many of the same materials that have been used in the industrial arena. There are also a large number of commercial bins that were built for storage of specialty products such as Pistachio nuts. Special sealing techniques were used on the roofs and sidewalls to make sure that required pressure could be maintained for the stipulated hours of fumigation. The challenge was to find ways to seal the large number of vents required for drying and aeration. Also, special methods had to be employed to seal off the fans and transitions where the air entered the bin.

In order to create the structural strength of roofs to withstand wind loads, ribs were formed in the panels. Sheets were then overlapped and bolted together. While this method created a weather-tight seal, it certainly does not create an airtight seam. However, putting caulking on top of the bottom sheet rib prior to bolting the sheets together appears to provide the necessary seal. A bigger challenge is posed at the roof and sidewall juncture. The roof panels are attached to the sidewall by the use of special brackets. The roof panel is straight and cannot fit tight against the curved wall-sheet. To seal this opening manufacturers have introduced an eave seal kit that will give the necessary airtight seal when properly installed.

The horizontal and vertical body seams can also be adequately sealed by the use of a special cell type tape-caulking. This is preferred over the convential butyl rubber rope-caulking used by most bin manufactures since heat does not affect its sealing qualities. It also covers a larger area that improves the chance of an airtight seal. The tape sealant covers the boltholes prior to bolting the sheets together. Even though the bolts have a washer on them that provide a weather-tight seal the tape gives added insurance. One of the problems often encountered

with the bolts is when the installer prefers to use the impact wrench on the head of the bolt rather than the nut. When this is done the washer is quite often damaged preventing a proper seal. The tape sealant provides protection against air leakage if the installer employs this practice.

It is also necessary to make sure that proper sealing techniques are incorporated at openings such as doors or aeration transitions. Even with care during the construction process it is difficult to ensure an air-tight seal. In most cases plastic has been taped over these areas. If this method is unacceptable then special doors will need to be developed.

Sealing of the bin when it is set down on the concrete pad also poses special needs for airtight seals. Often the pad is not perfectly level which creates a particular problem. For many years tar was used to seal this area. Then, over a period of years the tar would dry out and crack, and the seal was broken. A later development was the use of asphalt-impregnated foam to fit under the base angle on the bottom sheet. If the flange was wide enough and flat enough, this proved to work very well with level concrete. However, frequently the contractor would have to move the bin to make sure it was perfectly round, and in so doing would roll the foam out from under the base angle. Today a system has been developed that will completely seal the area between the bin and the concrete. The two-step process consists of an application of a sealant and a fabric. The major objection to this system is the initial cost. However it does give the airtight seal that is required. While there are examples of successfully sealing bins for fumigation, the industry certainly is not yet in a position yet to say that it can build all bins for CA conditions. The first challenge for the bin manufacturers is to have a good concept of just what "sealed" really means. We need to know the pressure requirements and the length of time that the pressure must be maintained. The manufacturer and industry must also determine how to properly install the aeration requirements for such a structure. Special vents will need to be developed in order to make sure that they can be sealed without someone going onto the roof to cover them with plastic. There will be the concern of making sure that vents are open when fans are turned on. There will also need to be answers on how to prevent condensation on the roof panels when the bin is sealed.

We will also need to educate the consumer as to why payment of a premium for this structure over a conventional bin can be justified. Economic justification will be essential. However, a bigger challenge for both the manufacturer and the consumer will be to convince the bin contractors that they must take the time and care for undertaking proper installation. The manufacturer can design a bin to be properly sealed, but if proper construction procedure does not follow, the final result may be less than desired.

If researchers are willing to work closely with bin manufacturers, systems can be developed that will meet the needs of the industry. But just as important will be the education of the end-users so as convince them that the up-front additional cost can be recovered in lower operating costs and reduced grain losses. Much of the work in identifying materials to carry out the sealing technique has already been accomplished. The biggest challenge now comes in convincing the consumer that the additional cost is justified, and in convincing the contractors that they must take the extra time to properly seal the bin during the construction process, even when they know that they will be paid for the extra time. Training of the construction crews will be more important than it has ever been.

Sealing of grain bins to maintain a controlled environment atmosphere can be adequately addressed if all contributing professions are made aware of the final objective and are educated on how the additional initial costs will more than pay for themselves in the life of the structure. The real challenge will not be in building new bins to meet increased storage needs but will be in trying to determine if the thousands of existing structures can be modified for this purpose.