Proposal #8

Proposal
Texas A&M AgriLife Research Air Quality Research Program
FY 2014-2015

Title: Preventing Grain Dust Explosions by Reducing MECs in Grain Handling Facilities

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Amount Requested per year: $ 100,000 FY 2014; $ 100,000 FY 2015

Executive Summary

Dust explosions at grain handling facilities continue to occur in spite of decades of research, regulation, and preventative measures. A systems approach to a solution reveals that dust explosions may only occur when four conditions are met: ignition source, oxygen, containment, and fuel. Fuel for dust explosions is present in the form of a minimum explosive concentration (MEC), which is the concentration of dust entrained in air which will allow a flame to self-propagate through the dust cloud. Reducing MECs should be a major goal in explosion prevention, yet this has not been addressed by industry or regulatory agencies. Particularly noteworthy is that air pollution regulations currently mandate the use of bag filter houses to control dust emissions. Due to the nature of their operation, every bag filter is a source of multiple continuous MECs.

Grain handling facilities are required to install bag filters at all points where particulate matter (PM) is emitted in order to obtain operating permits from the respective State Air Pollution Regulatory Agencies (SAPRAs). It is likely that properly designed 1D3D cyclones could be used to sufficiently abate the PM such that the public off property are not impacted. The justification for requiring bag filters is that EPA has assumed that the capture efficiencies of cyclones are too low. The cyclone efficiencies of most agricultural PM can exceed 95%. These high efficiencies are because the particle size distributions of most agricultural PM are much larger than what had been reported. Most of the PM emitted by grain elevators and feed mills can be represented by lognormal distributions having mass median diameters (MMD) ranging from 15 to 30 micrometers (μm) aerodynamic equivalent diameters (AED) and geometric standard deviations (GSD) ranging from 1.6 to2.4.

Pulse-jet bag filters operate by forming a dust layer/cake on the outer surface of the bag. The smaller particles are captured by the cake. When the pressure of the air passing through the cake reaches a preset point, compressed air is released inside the bag causing the particulate matter to leave the bag surface and fall by gravity to the collection point at the bottom of the bag house. The rate that this bag cleaning occurs can vary from one to two per hour. Each time that it occurs, a minimum explosive concentration (MEC) exists with the dust falling into the collection point. One approach to reduce the number of explosions at grain handling facilities is to reduce the number of MECs. There is a need to change the SAPRA criterion for obtaining a permit for grain handling facilities by requiring bag filters.

The goal of this research is to demonstrate that properly designed and constructed cyclones can be used to abate grain dust such that the concentration of PM10 and PM2.5 at the property line and beyond is less than the National Ambient Air Quality Standards (NAAQS). An

added advantage of using cyclones is that there will be no MECs in contrast to the pulse-jet bag filters.

Dust Explosions:

Historically, the number of dust explosions at industrial facilities range from 10 to 20 per year. A grain dust explosion is a series of explosions: a primary dust explosion, followed by one or more secondary explosions. The primary dust explosion is the result of ignition of an MEC, followed by a rise in pressure that results in the bursting of the initial containment and the formation of a pressure wave and fire front. The pressure wave moves away from the primary location at or slightly less than the speed of sound (330 m/s). The turbulence caused by the pressure wave in a new and larger chamber entrains residual dust into a secondary MEC. The fire front follows the pressure wave at a much slower rate (2 to 10 m/s) and ignites the new MEC resulting in a secondary dust explosion. The pressure of the primary explosion is typically less than 2 psig whereas the pressure from secondary dust explosions can exceed 150 psig. One approach to prevent dust explosions is to reduce the number of MECs. Forcing all grain handling facilities to use bag filters to abate dust emissions from grain handling is increasing the probability of a dust explosion.

History:

Much can be learned by reviewing what was done (and not done) in the period following the major explosions in Westwego, Louisiana and Galveston, Texas on December 22, 1977 and December, 27, 1977, respectively. The number of employees killed in these two explosions numbered 53 with 32 injured. Congressional Hearings (1978) were held chaired by Congressman Gaydos. It is standard form for all federal agencies to be involved in these hearings. There are those who seek to provide answers for how two large export elevators could have been destroyed in a period of less than a week. We are having explosions today. Imperial Sugar (2-07-2008) and Atchison KS (10-29-2011) are two examples of more current dust explosions that have resulted in loss of life. Why are we having devastating dust explosions in 2013? The answer is that we not invested in research designed to prevent dust explosions. We are expecting OSHA and EPA to prevent dust explosions. The following are excerpts from the hearings:

1. Parnell (OSHA, 1978) submitted written testimony (pp. 1144-1148). The following are portions of that testimony:

   "*The occurrence of grain dust explosions is not new. As reported in the fire protection handbook, there are 1,200 such explosions in the U.S. and Canada between 1860 and 1957. Many more explosions than this probably occurred and were not reported because of the absences of casualties and smallness of loss….*
   Currently, OSHA is putting extreme pressures on the grain industry to decrease the probability of grain dust explosions by controlling one element of the three elements required for a dust explosion. That one element is the ignition source. The tremendous

pressure by OSHA on the grain industry to adhere to safety principles to control ignition sources has caused the industry to invest heavily in equipment which may or may not prevent dust explosions. …
In my opinion, the research effort in the U.S. on preventing grain dust explosions has been limited the last 10 to 15 years….
Each time grain is handled in the processing point, dust is created from the grain itself."

I go on to recommend that we should reduce the dust content of grain delivered to the feed mills and grain elevators. I point out that the collected dust can amount to 2 to 6 pounds per ton of grain and care must be taken to insure that the handling of this dust will not result in an MEC. I recommend that funding to reduce dust explosion be increased. I believe that my testimony in 1978 is still true today!

Air pollution regulations impacting the number of grain dust explosions:

Mr. David Hawkins Assistant Administrator for Air and Waste Management addressed the claim that it was EPA regulations were responsible for the increase in the number of devastating grain dust explosions. (page183). This was a popular position during these hearings. The claims have merit. SAPRAs were required to limit emissions from air pollution abatement equipment installed on grain handling facilities to less than 0.01 grains per dry standard cubic foot (gr/dscf). (The limit of emissions from hazardous waste incinerators was 0.08 gr/dscf.) It was perceived by most permit engineers that pulse-jet bag houses were the only abatement equipment that could meet this standard. This popular position was stated in the Editorial in the Galveston Daily News on January 6, 1978 as follows:
"*The loss of human lives and infliction of suffering in the recent grain elevator explosions because of bureaucratic regulations for a 'clean environment' is sheer insanity and must be stopped.… Apparently, all our scientific technology has been unable to devise methods of preventing these tragedies…. Congress must take emergency immediate action to grant a moratorium to grain elevator operators throughout the country on enforcement of rules and regulations imposed by the EPA and OSHA.*" In other words, the blame for the explosions was a consequence of EPA and OSHA forcing grain elevators to keep the dust inside the elevator rather than releasing it to the environment.

Mr.Hawkins" response was as follows (pg. 178): "*I would like to turn now to the question whether pollution control requirements are somehow connected with any of the grain elevator explosions. The facts are that good air pollution control practices do not increase the risks of fires or explosions.*" Mr. Hawkins was not necessarily correct. To prevent dust explosions, we must reduce the number of MECs in the grain elevator or feed mill! Handling grain dust collected by pulse-jet bag houses will result in MECs. If the dust were captured by cyclones and immediately returned to the grain stream, there

would be reductions in the number of MECs. It is counter intuitive but the result of the study on the impacts of prohibiting recombining recirculation dust at export elevators concluded that putting the dust back into the grain stream immediately after it was collected by the abatement equipment would result in fewer dust explosions.

Goals and Objectives:

The goal of this research effort is to develop the technology that would result in fewer dust explosions. It is hypothesized that by reducing the number of MECs in an elevator or feed mill, we can reduce the probability of a dust explosion. **Fewer MECs = Fewer Explosions!**

The technology needed to reduce the number of MECs in grain handling facilities is not simple nor is it low cost. If the concentration of dust in air at a grain transfer point in a grain handling facility is less than the MEC, no primary explosion will occur even if an ignition source, oxygen, or containment exists. Cyclones can be designed to comply with EPA and SAPRA emission limits without generating MECs. Our research objectives are as follows:

1. (Year 1) Develop a ventilation system design that will result in reducing the concentrations of grain dust at all grain transfer points in the elevator or feed mill to less than the MEC. It is possible to remove sufficient dust entrained in air at grain transfer points using ventilation such that the concentration is less than the MEC.

2. (Year 1) Demonstrate the reduction of MECs in grain handling facilities using cyclones instead of bag filters. We know that pulse-jet bag houses have MECs in their normal operation. By replacing bag houses with cyclones, we will significantly reduce the number of MECs.

3. (Year 2) Demonstrate compliance with air pollution regulations at grain handling facilities with the use of cyclones. By using cyclones instead of pulse-jet bag houses, we use safer and cost effective abatement systems to comply with EPA and/or SAPRA standards.

4. (Year 2) Perform the economic analysis that will be required to justify replacing all pulse-jet bag houses at grain handling facilities over time with properly designed cyclones in a timely manner. Using cyclones instead of pulse-jet bag houses, we reduce the cost of abatement equipment to comply with EPA and/or SAPRA standards. The cost of purchasing and operating bag houses is approximately $5 to $10 per cubic foot per minute (cfm). In contrast, cyclones can be designed and operated at less than $2 /cfm. One bag house designed to remove PM for 15,000 cfm could cost as much as $150,000 (Parnell et al. 1991). In contrast, this same system would cost less than $30,000 using cyclones.

5. (Year 2) Conduct systems analysis to determine best practices of dust disposal. It is essential that all dust handling be accomplished without increasing the number of MECs.

Expectations or Significance

Using cyclones instead of bag houses will result in a major reduction in expenses for grain handling facilities. More importantly however, the reduction of MECs will reduce the probability of dust explosions. In the past, it has been assumed that EPA and SAPRAs had the appropriate justification for requiring bag houses for operating permits. With this research, it will be demonstrated that cyclones can be used to comply with EPA and SAPRA air quality standards. All grain transfer points will have MECs. By developing a ventilation system that will prevent MECs from forming at grain transfer points, no primary dust explosion can result even in the presence of an ignition source. If there is no primary, there will be no secondary explosions.

A critical concept of this research is the use of science and technology to reduce the number of MECs. Handling grain dust that is separated from the grain such that no MECs will result during the collection and ultimate destination will be a major challenge. Parnell et al (1991) reported several methods for handling separated grain dust. Whatever method is recommended for handling separated grain dust in this research must not increase the number of MECs. It is expected that if all potential MEC locations are eliminated, the probability of a dust explosion will be greatly reduced or eliminated.

Budget and Resources:

Project Duration (1st Year): Item	FY2014 Request ($)	FY2015 Request ($)
Salaries & Wages	100,000	100,000
Operational Costs	0	0
Capital Equipment	0	0
Other		
Travel	0	0
Supplies	0	0
Tuition and fees	0	0
Other	0	0
Indirect Costs	0	0
TOTALS	100,000	100,000

This proposal leverages other sources of funding and existing equipment from other projects as well as the resources of the CAAQES laboratory. This budget represents a portion of the real cost of the proposed research and includes partial salary for one graduate research assistant and one assistant research scientist and student workers. Non-salary costs will be borne by other funding. Additional funding for research will be used to supplement this research effort as it becomes available. Funding from multiple sources is critical to making the anticipated progress on the project objectives.