2. Executive Summary

The purpose of this report was to investigate explosion relief venting in grain silos, using the current design configurations and the current NFPA and European guidelines. The study makes use of equations and published information as it appears in NFPA or European standards as they apply to Deflagration venting and no attempt has been made to determine the validity of this published data. As you will see in the report there are many factors involved in the sizing and positioning of any potential explosion relief panels, as well as the design of the grain storage silo.

Grain storage and handling has evolved in many ways over the last 100 years to help reduce the risk to life and property from the hazards of grain dust explosions. As many already know, early silos and grain elevators were built totally enclosed and the prominent construction material was wood. Then as production and infrastructure improved they moved to concrete; this was around the turn of the 20th century. Presently grain elevator construction uses materials including concrete and steel, but predominantly a more open type construction to reduce containment needed for an explosion to occur. Silos, or grain storage, have gotten larger with generally less segregations. This evolution has occurred for several reasons including market demands, shuttle trains and better controls for damage to the grain.

Various investigations over the years into the root causes of explosions have led to improvements in facility design by isolating the more hazardous equipment combined with additional explosion venting. While at the same time, identifying sources of ignition has led to improving hazard monitoring such as temperature monitors, rub sensors, inline magnets, etc. Design changes combined with better housekeeping and operator training has resulted in greatly reducing the ignition sources, thereby lowering the risk of explosion.

Following is an overview or our findings related to explosion mitigations in grain silos.

For standalone concrete grain silos it is possible to add explosion venting to the sidewalls of bins. Adding these vents would increase the cost of construction plus the cost of the vents themselves. This would cause either a loss of capacity or increased height to maintain the same capacity. Specific calculations and venting requirements can be found in Section 7 starting on page 7.1. Opinions on cost to construct can be found in Section 9 starting on page 9.1.

Clustered grain silos provide their own challenges to adequate venting and the resultant loss of capacity. First, we would lose the use of interstitial bins because they cannot effectively be vented. Secondly, the outside corner bins would lose approximately 15% capacity while the inside bins would lose up to 30% depending on bin diameter. The loss of capacity is due mainly to limited wall space to install explosion vents. Specific calculations and venting requirements can be found in Section 7 starting on page 7.3.

For steel storage bins, vents could be added to the sidewall again with a loss of capacity or an increase in bin height to maintain the capacity. Other problems are encountered when attempting to add vents to the steel sidewall panels. The sidewall sheets are not currently designed to have large square sections of them removed. Stiffeners add to the factor limiting size and location of the vents. Lastly, adding vents to these bins would require additional engineering from the bin supplier. Another major factor is in sealing the vents against the weather. The corrugated panels do not lend themselves well to adding flat vent support frames. Sealing against wind and water would be a major problem and would become a continual long-term maintenance item. When we consider that there would be upwards of 85 vent panels on a 105 ft. bin, maintenance would be a major factor. We also looked at adding venting to the roof of steel bins and only the largest bins had enough usable area to add the vent required. Specific calculations and venting requirements can be found in Section 7 starting on page 7.4.

Lastly, the cost of vent panels alone represents a substantial investment. The cost for each vent panel is estimated at $5700, so even in a small bin with 34 vents it represents a $193,800 investment plus additional engineering and installation. This will be covered more fully later in the study.

Currently the NFPA does not allow for partial volumes in the bins. Using current standards the vent area calculations must take into account the longest flame path with the bin empty. It is felt that it would take some interval of time during filling for an empty bin to reach a minimum explosive concentration; therefore the longest flame path during a deflagration may not necessarily be when the bin is entirely empty but rather at some point during filling. This smaller volume would have a definite impact on the number of vents required and subsequent monetary investment.

Additionally, it may make more sense to look at limiting risk by eliminating the dust or Lower Explosion Limit (LEL) from the bins or by removing any potential ignition source from the bins. Dust could be limited (less than 25% of LEL) by means of ventilation and/or controlled filling. The dust levels could be monitored so that they never reach 25% LEL therefore removing the risk of a deflagration. This would require additional research and design. Another method may be to remove any potential ignition source from the bin. By installing a “Slam Gate” or extinguishing system controlled by a spark detector and/or an infrared heat detector, ignition sources could be kept out of the storage bin. Again, this would require additional research and design.