2016 Summary of U.S. Agricultural Confined Space-Related Injuries and Fatalities

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Introduction

This publication represents continued efforts by Purdue's Agricultural Safety and Health Program to gain a better understanding of injuries and fatalities that occur inside agricultural confined spaces, including grain storage and handling facilities. The purpose of these efforts is to contribute towards the reduction in the frequency and severity of these incidents. This summary is based on data gathered, documented and entered into Purdue's Agricultural Confined Space Incident Database (PACSID). Partial support for this year's surveillance effort was provided by The Grain Journal (www.grainnet.com).

No fewer than 60 fatal and non-fatal cases were documented in 2016. Of these, 30 (50%) were fatal and 29 (48%) of those cases were directly related to grain entrapments. In addition to the cases documented in 2016, cases that occurred in previous years continue to be added to the database due to ongoing discovery efforts. The total number of cases[1] documented between 1962 and 2016 and entered in the PACSID is 1,935. Of those, 1,187 cases (61%) were reported as fatal and 1,432 (74%) involved grain storage and handling facilities. As noted in past summaries, the data presented do not account for all incidents involving agricultural confined spaces. There is no accumulative public record of these incidents due to the fact that there is no comprehensive or mandatory incident/injury reporting systems for most of agriculture; in addition, there has been reluctance on the part of some victims and employers to report non-fatal incidents, especially at farms, feedlots and seed processing operations. It is estimated that approximately 30% of cases go unreported.

[1] There is one case in the database that occurred in 1956.

2016 Summary of Agricultural-Confined Space-Related Cases

In 2016, there were 29 documented grain entrapment cases[2], 11 falls into or from grain storage structures, ten asphyxiations due to toxic environments, and eight equipment entanglements that occurred inside agricultural confined spaces (Figure 1). Grain entrapments accounted for 48% of the documented cases. For incident types with more than one case, asphyxiations and falls had the highest fatality rate reported at 100% and 64% respectively, while grain entrapments ranked third with a 38% fatality rate. Similar to 2015, the number of fatal cases was equal to the number of non-fatal cases for all confined space incidents; this is the second time that the number of fatal cases was equal to or greater than the number of non-fatal cases in the last six years. The 5-year and 10-year averages for non-fatal cases was 33.00 and 36.30 cases/year respectively. The 5-year and 10-year averages for fatal cases was 26.20 and 31.20 cases/year respectively. In comparison, in 2016 non-fatal cases (30 cases) were below average for both metrics, and fatal cases (30 cases) were either above or at average. It is speculated that the increase in percentage of fatalities could be due to a significant drop in the number of identified reports of non-fatal cases.

The 60 confined space cases represented a 25% increase in the number of cases documented in 2015, when 48 were recorded. This places the number of this year's confined space-related cases near the 5-year average (59.20 cases/year) and below the 10-year average (67.50 cases/year). The 5-year running average for confined space-related cases continued to decrease from its peak in 2011 of 75.8 cases/year to 59.2 cases/year; thus was the lowest reported five-year average since 2008. This marks the first significant decrease since the five-year average started to steadily increase in 2002 from 36.8 cases per year. A significant contributing factor in the earlier increase in the frequency was attributed to better documentation of incidents due to more aggressive surveillance efforts and increased access to case information via the internet.

[2] A case refers to one individual. Some incidents involved multiple individuals or cases.

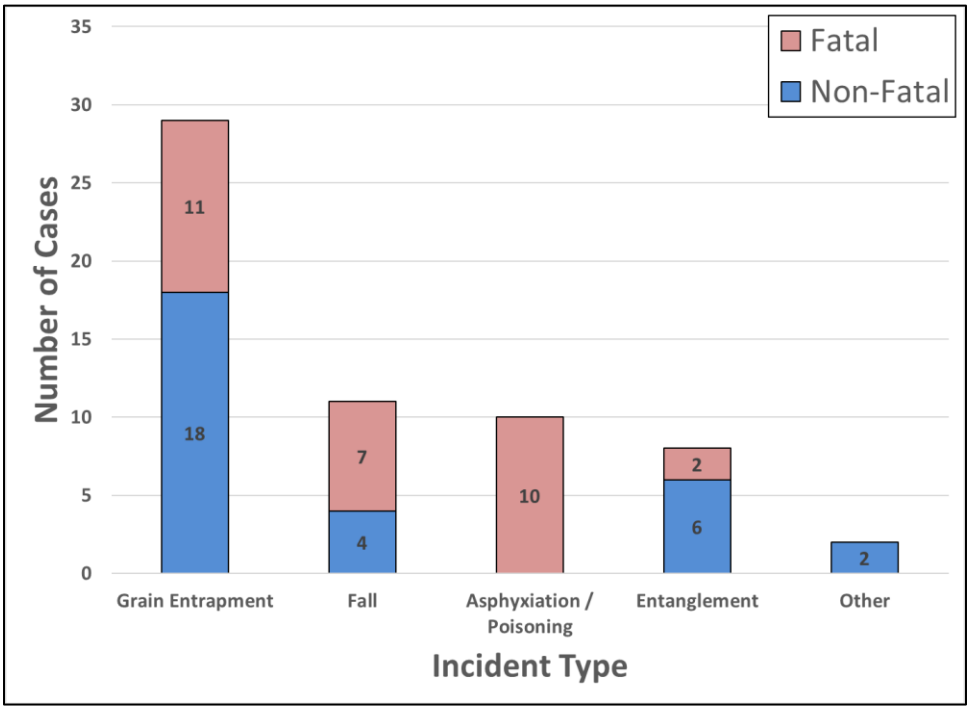

Figure 1: Distribution of all 2016 agricultural confined space-related cases by type of incident.

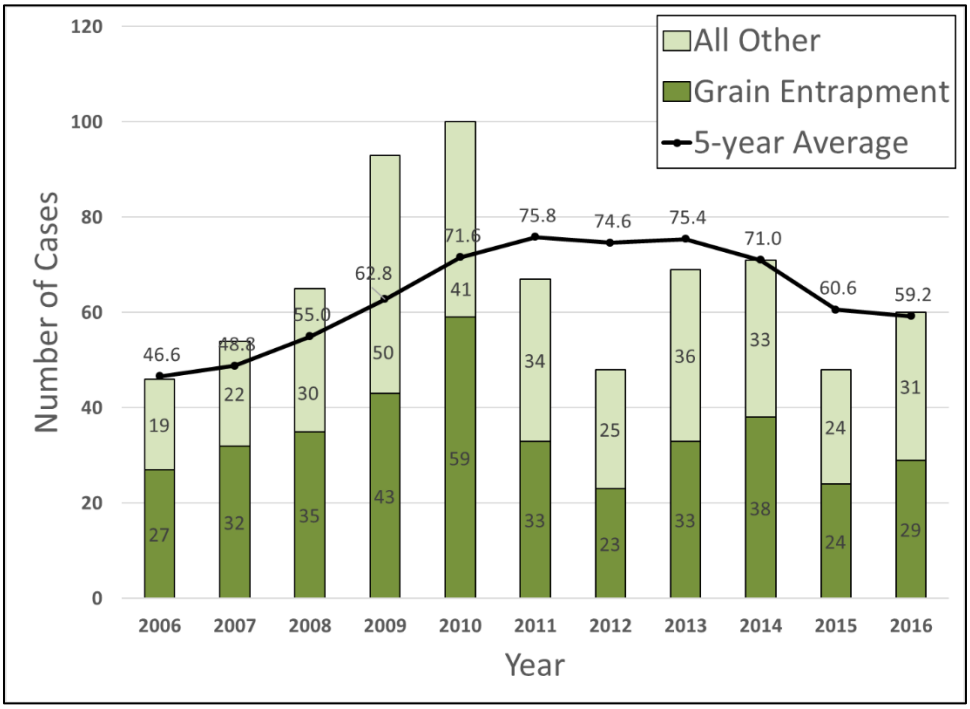

Figure 2: Number of all annual confined space cases recorded between 2006 and 2016.

In 2016, the states with the most documented confined space cases of all types, including fatal and non-fatal, were Nebraska (7), Iowa (6) and Indiana (4). There were four cases each for Illinois, Kansas and Michigan, and three cases in Arizona, Minnesota, South Dakota and Ohio. Overall, incidents were documented in 21 states in 2016, similar to 2015. Figure 3 illustrates the geographic distribution of all documented cases in the PACSID. The three states with the largest number of cases are Iowa (228), Indiana (220) and Minnesota (184). As noted in previous summaries, it is estimated that this surveillance effort underreports cases by as much as 30% due to the lack of adequate reporting mechanisms.

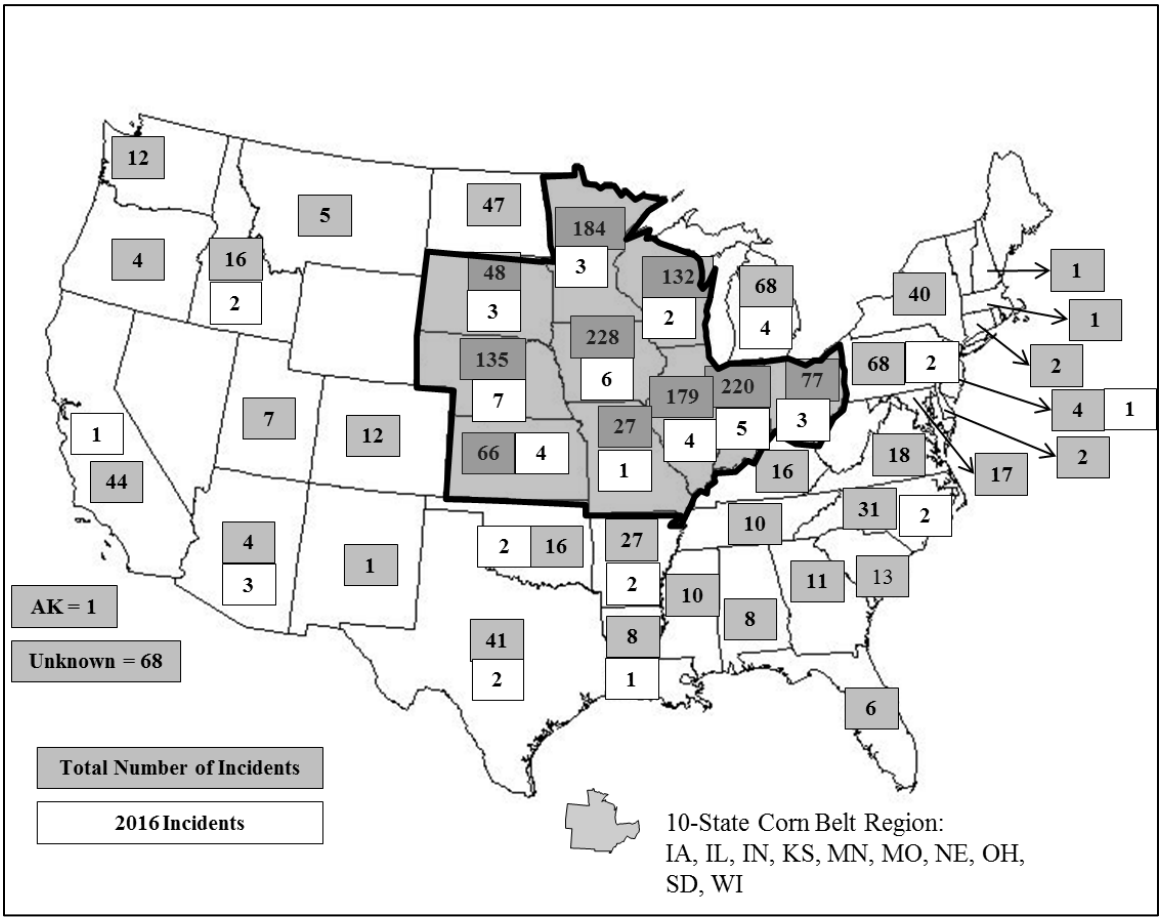

Figure 3: Geographic distribution of all confined space cases for 2016 and previous years (n=1935).

There were four cases in 2016 in which the gender was female and one where gender was unknown, the remaining cases all involved males. Three of the female cases occurred to girls under the age of 18 including a four year old. The age for the remaining female case was unknown.

In total, there were eight cases involving a child or youth under the age of 21, as shown in Figure 4. Overall, a specific age was known for 43 of the 60 victims in 2016, with the oldest victim being 79 and the youngest four years old. The average age was 44.6 years old, and the median age 43 (Figure 4). Those over the age of 60 accounted for 12 (28%) of the 43 cases (where age was known), reflecting the increasing average age of farmers (58 years old) in the U.S. As noted, a large number of the cases documented (17) did not include the specific age of the victim.

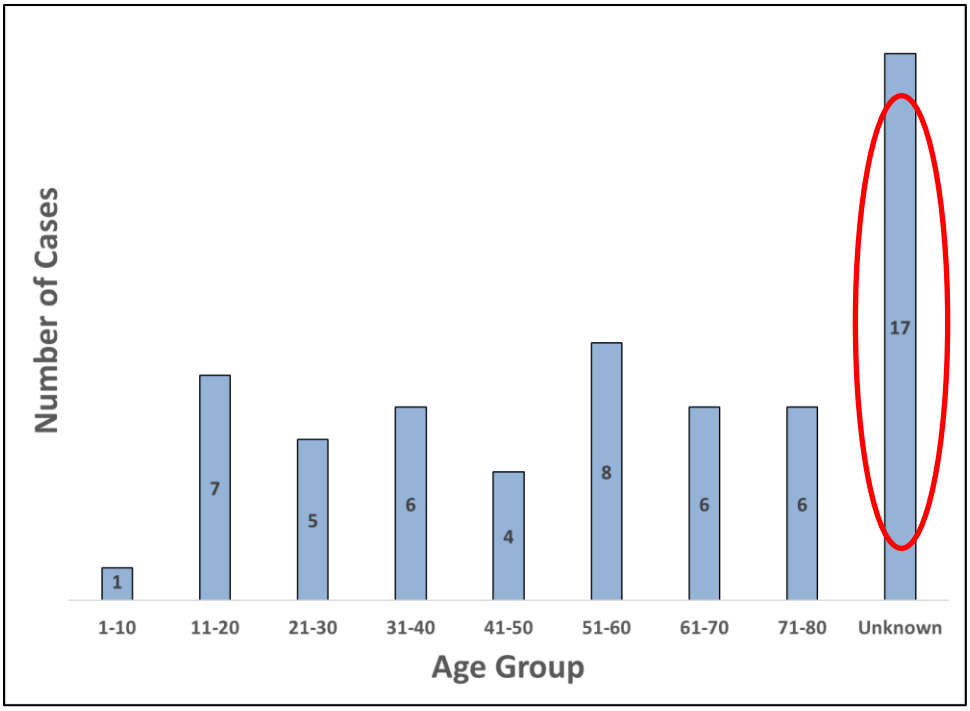

Figure 4: Age distribution of all 016 agricultural confined space incident victims by number of cases recorded.

It is interesting to note the comparison between 2016 agricultural confined space incidents and mining incidents. In 2015, there were 27 fatal mining incidents and 24 fatal confined space incidents. In 2016, however, there were 30 fatal confined space incidents, while only 9 fatal mining incidents. This was the first time that there was more fatal incidents involving agricultural confined spaces than mining since 2009. For more detail on comparisons between these two industries, please review the 2015 Summary on Agricultural Confined Space-Related Incidents at Purdue's website: www.agconfinedspaces.org.

Grain Entrapments

The 29 grain entrapment cases documented in 2016 represented a 21% increase from 2015 when 24 were recorded. The total number of cases documented in 2016 is very close to the 5-year average (29.4 cases/year). Note, the 5-year running average continues to drop from its peak of 40.4 in 2011 (Figure 5). The number of fatal cases (11) is the second lowest recorded since 1985, only 2012 reported lower number of cases (8). While, the number of non-fatal cases (18) was the fourth largest ever recorded after 2010 (27), 2011 (21), 2013 (21), and 2014 (20). The fatality rate was 38%, lower than 5-year average (43%). In 2016, the state with the most documented grain entrapments, fatal and non-fatal, was Indiana with five cases total. This was followed by Nebraska (4), Iowa (3) Minnesota (2), and the remaining 10 states had one or two each. Overall, entrapments were documented in 14 states in 2016. The majority of grain entrapment cases occurred in the Midwest, or Cornbelt (77%), similar to last year during which 79% occurred in the Midwest. This contrasts with 2013 in which 61% of the cases occurred in the Midwest. Figure 6 provides a geographic distribution of all documented grain entrapment cases contained in the PACSID where the location was known. Indiana continues to have the highest number of grain entrapment cases. It is believed that this high number reflects more aggressive surveillance efforts in Indiana to document both fatal and non-fatal cases over the past 40 years rather than an actual larger number of cases.

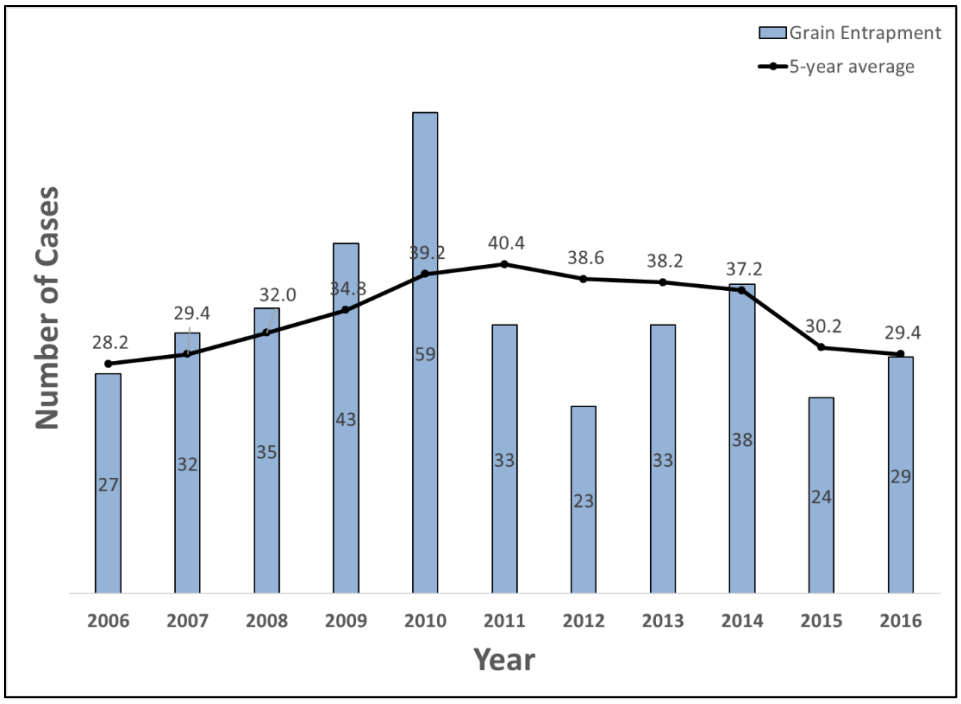

Figure 5 Number of annual grain entrapment cases recorded between 2006 and 2016.

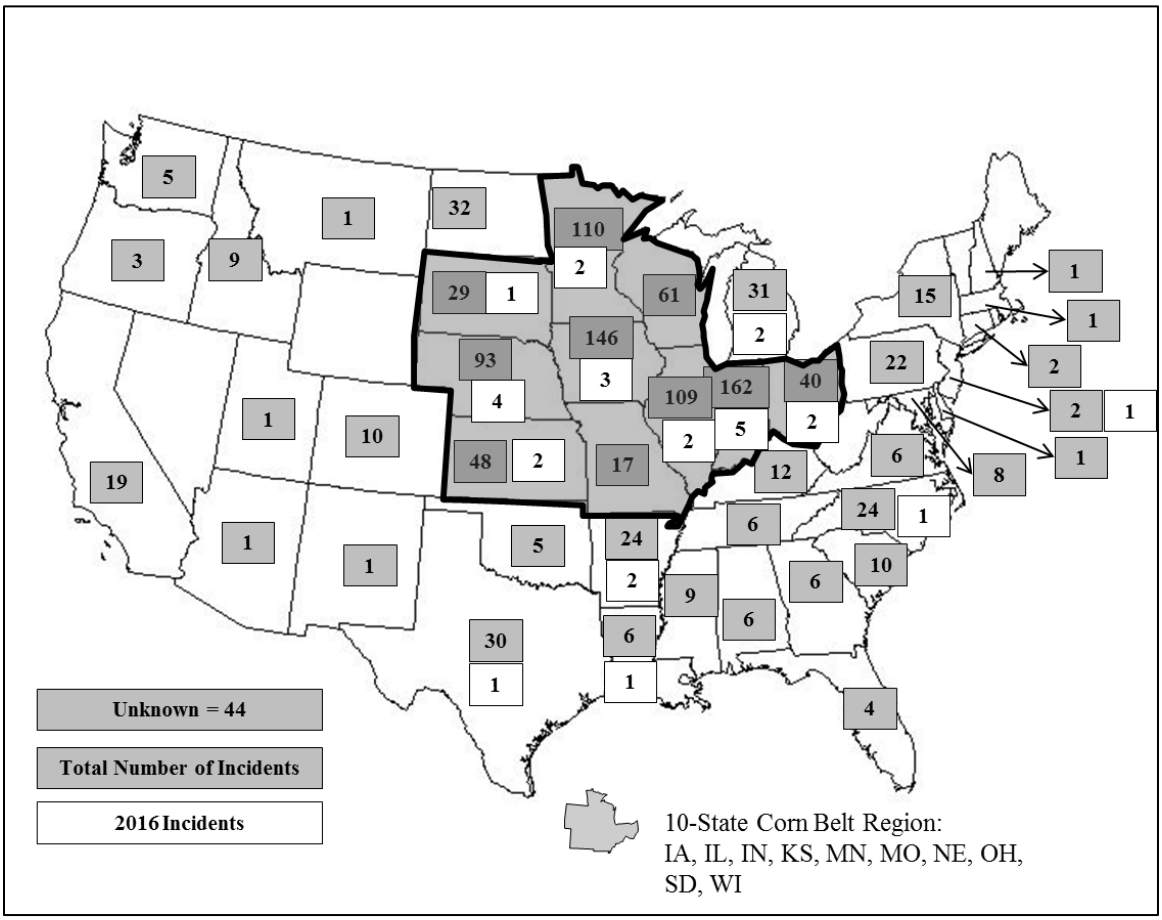

Figure 6: Geographic distribution of grain entrapment cases for 2016 and previous years (n=1172).

In 2016, there were 26 cases where the exemption status[3] of the facility with respect to OSHA regulations was known. Of those, 16 (62%) occurred on farms or other locations currently exempt from compliance with the OSHA Grain Handling Facilities Standards (29 CFR 1910.272), with the balance of 10 (38%) taking place at non-exempt commercial grain facilities. This is in contrast to both 2014 and 2015 in which 82% of all grain entrapment cases occurred at exempt facilities. It is important to note that there were only three cases in 2016 in which the exemption status was unknown; and it is believed that the majority of the unknown cases, based on historical data, have OSHA exempt status.

The victims were female in only two cases. In one case, the gender could not be determined. The remaining cases (26) were male victims. There were five cases involving a youth under the

[3] Under the current provisions of the two OSHA workplace safety and health standards most relevant to agricultural confined spaces, most agricultural worksites, including most farms, feedlots, and certain seed processing operations are exempt from compliance.

age of 21. This represented 28% of all cases in which the age was known (18) and is a sharp contrast to 2015 in which there was only one case below the age of 21 (Figure 7). The oldest victim was 79 and the youngest, 4 years old. The average age was 45 years old and the median age 42. Three cases of grain entrapments occurred in grain transport vehicles (GTV), in contrast to 2015 in which none were reported in GTVs. Of these, two resulted in a fatality.

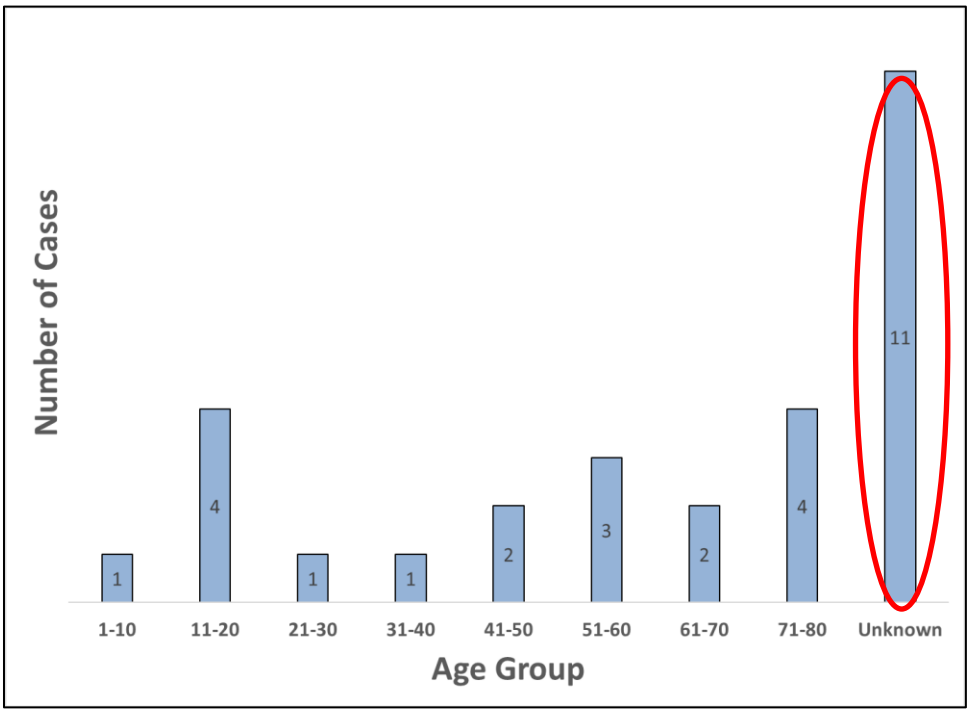

Figure 7: Age distribution of 2016 grain entrapment victims by number of cases recorded.

During 2016, the primary medium of entrapment, when identified, was corn (9 cases, 30%). Soybeans were the second most common grain with four cases (13%) and wheat was in third place with 2 cases (7%). The medium was not known in 15 cases (50%). Out-of-condition grain continues to be the most significant contributing factor. Vertical and horizontal crusting that leads to difficulty in removing residual grain was frequently identified in case reports.

As in past years, it should be noted that this summary does not reflect all grain-related entrapments, fatal or non-fatal, that have occurred. Currently, over two-thirds of grain storage capacity in the U.S. is found on farms that are exempt from the current OSHA injury reporting requirement standards.

Summary of Documented Silage Unloading System Incidents

As tower silos continue to age and farmers shift away from silos to bunk storage and bagged silage it was anticipated that the frequency of these incidents would decline. The data appears to support this position. Incidents involving silo unloaders and unloading systems appear to be attributed to the age of the existing equipment and the introduction of new technology such as silage bagging equipment. The PACSID database contains 41 cases documented with four additional related cases not in the database[4] (Figure 8). In contrast to grain entrapments, where the fatality rate is approximately 43%, the overall fatality rate of silo unloader cases was 36%. These incidents have occurred over a forty-year span with the earliest one in 1974 and the latest one in 2015. The vast majority of these incidents occurred between 1987-1996 in which 24 cases where documented. The majority of these incidents occurred in Wisconsin (11) and Minnesota (9). Followed by Pennsylvania (6) and Iowa (5). In total, these incidents occurred in 9 states[5].

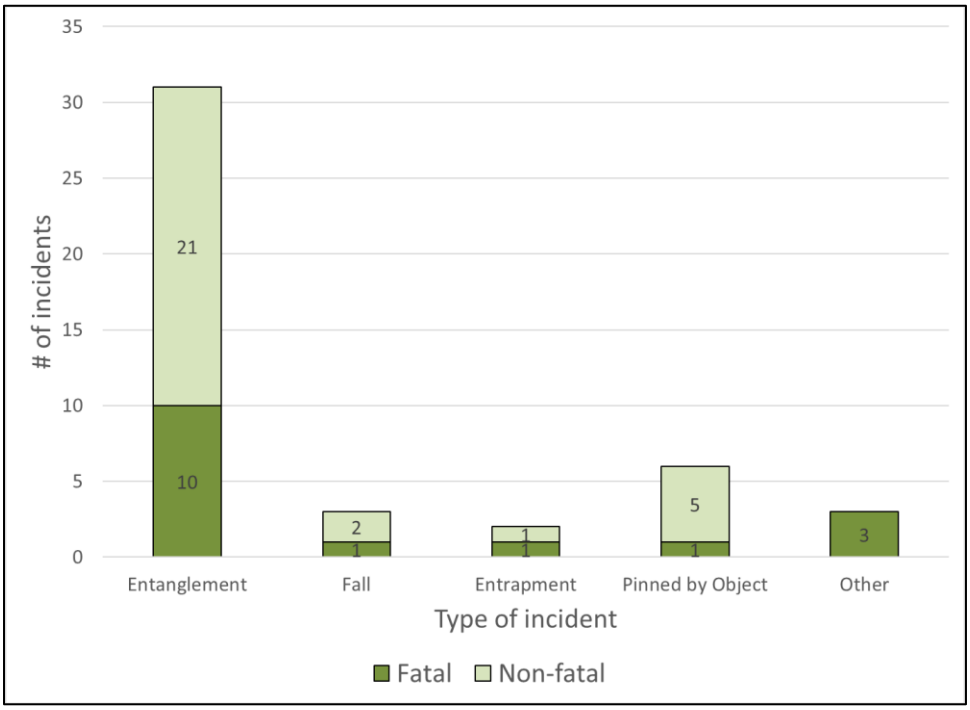

Figure 8: Unloading system incidents by type of incident and fatality.

There is no evidence to suggest that the frequency of silo unloading system incidents, of any type, is on the rise. It is believed that these incidents, however, are under reported because nearly all documented cases have occurred on farms exempt from OSHA reporting requirements.

[4] One case is an electrocution case involving the silo unloader but outside of a confined space. Three other incidents documented were silo unloader entanglements that occurred between 1987 and 1996 in Wisconsin. These three cases are unique (unaccounted for in our database), but are not included since the year of the incident is a required input for the PACSID database.

[5] There were four incidents in which the state was not known.

Analysis on the Distribution of Incident Type and Facility by US and OSHA Regions.

The vast majority of documented cases occured in grain storage facilities (1432), in the Midwest (1411), and are grain entrapments (1172). In previous summaries, the distribution of cases by region, location and incident type highlighted the significance of the above facts. Figure 9 compares all case types as a percent of total cases in each region. While grain entrapments are dominant in all four regions, there is a significant difference in distribution. In the Midwest and South regions, grain entrapments represent more than 60% of the cases, while falls, asphyxiation, and entanglements each represent about 10% of the cases in those regions. In comparison, grain entrapments represent about 40% of East region incidents and 50% of West region incidents. The West experiences below average numbers of fall cases (5% vs 10%) and a larger than usual amount of asphyxiation cases (20% vs 10%). The East experiences above average number of cases for asphyxiation (20% vs 10%) and entanglements (20% vs 10%). The unknown cases follow percentage trends very similar to both Midwest and South regions indicating that they most likely come from those regions.

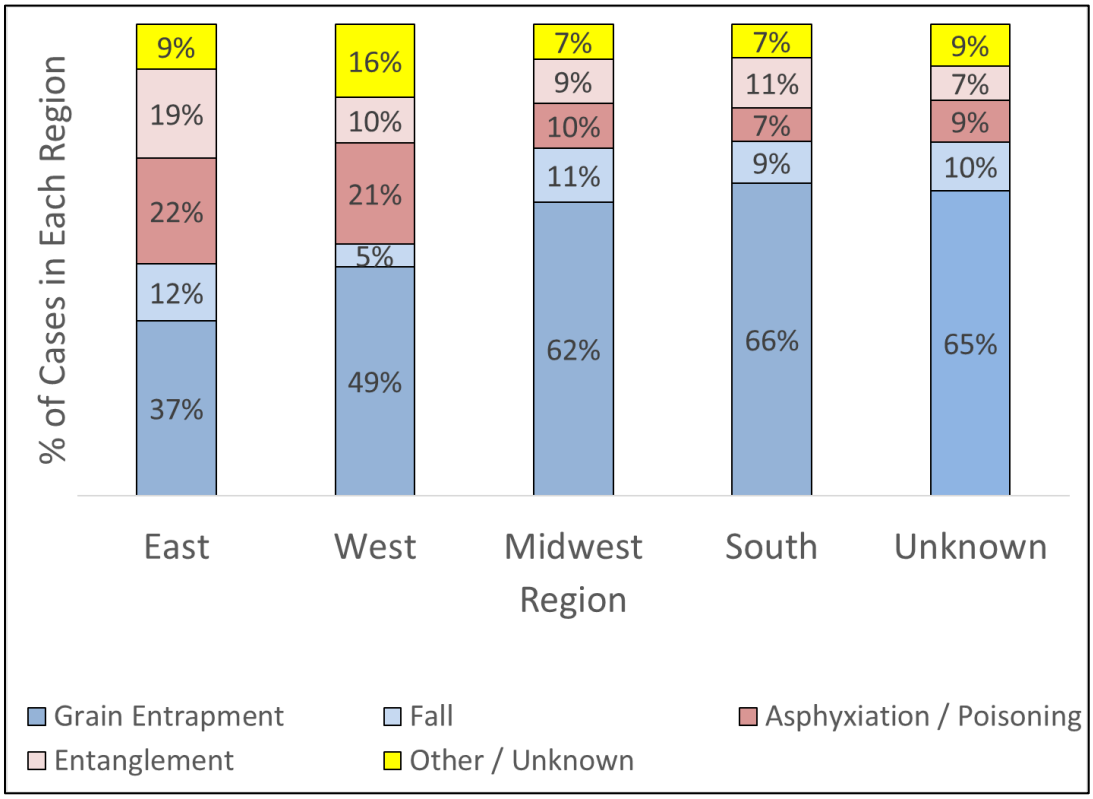

Figure 9: Agricultural confined space-related case distribution by region and incident type.

A review of the cases by type of facility generates similar trends. In the Midwest and South, grain storage facilities continue to represent the vast majority of cases (75-80%). The remaining cases are equally split between manure storage structures, agricultural transport vehicles and other cases. The only difference is that while the South has a negligible amount of cases in forage storage structures (1%), about 4% of the Midwest cases occur in these facilities. The West and East regions share similar distribution for grain storage facilities (55%). However, they tend to differ in distribution of cases in the remaining facility type. In the East region, 20% of the cases occur in forage structures, 14% in manure storage structures and 8% in agricultural transport vehicles. In the West region, 17% occur in manure storage structures, 12% in agricultural transport vehicles and only 2% in forage storage structures.

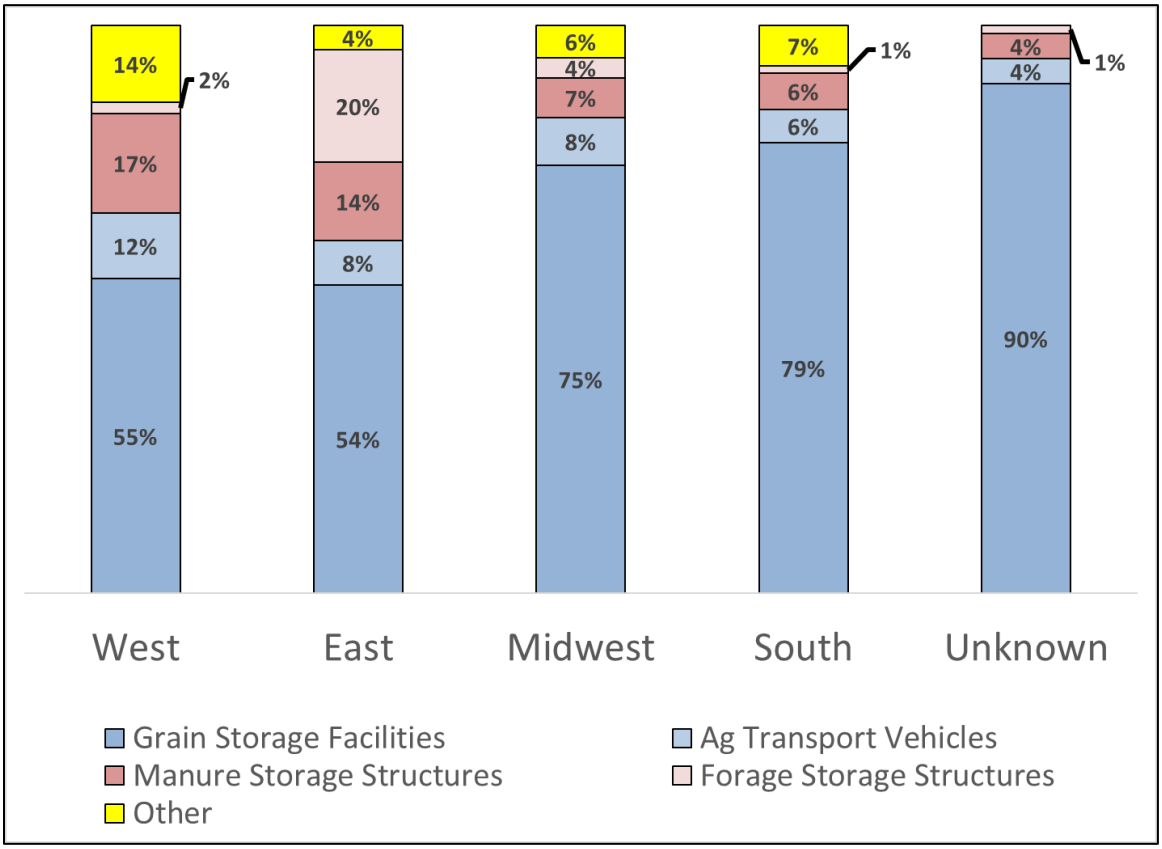

Figure 10: Confined case distribution by facility type and region

Confined space-related cases occur in every OSHA region but are mainly condensed in two regions, region 5 and 7. Region 5 contains 44% of all confined space cases (860) with 60% of those cases are grain entrapments, and 13% are falls. Region 7 contains 24% (456) of all cases with grain entrapments, asphyxiation and entanglements representing 67%, 11% and 10% of

those cases respectively. Region 1 represented the region with the smallest number of grain entrapments and region 4 represents the region with the largest percentage of total documented cases being grain entrapment cases (73%).

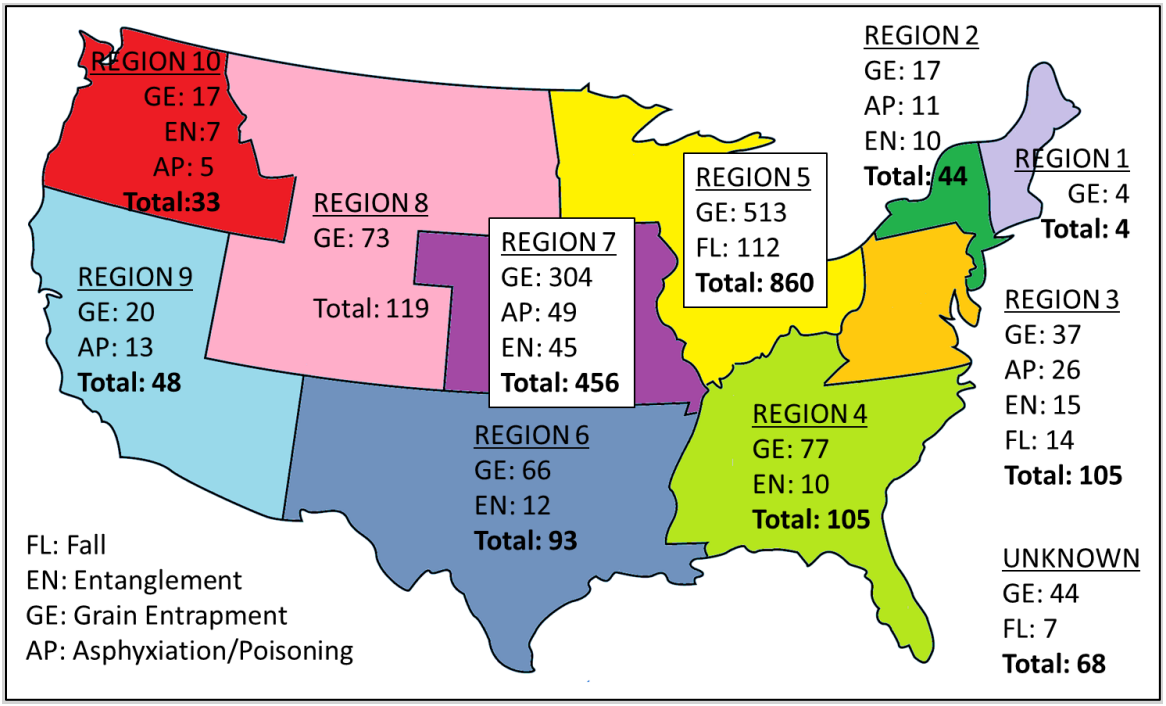

Figure 11: Confined case distribution by OSHA region from 1962-2016. The total number of cases and most frequent type of case is listed for each region (n=1935).

Observations

The following observations highlight several significant findings.

- No fewer than 60 fatal and non-fatal cases involving agricultural confined spaces were documented in 2016, representing a 25% increase over 2015.
- 48% of all cases documented involved grain-related entrapments as compared to other cases involving falls, entanglements, and asphyxiations.
- 50% of 2016 cases were fatal compared to 61% historically.
- Nebraska, Iowa, and Indiana reported the most cases in 2016 with Iowa, Indiana, and Minnesota being the overall leaders historically.
- There were 29 grain entrapments in 2016 representing a 21% increase over 2015.
- Indiana, Nebraska, Iowa, and Minnesota reported the most grain-entrapment cases in 2016. Historically, Indiana, Iowa, and Minnesota and Illinois have reported the most cases.
- 28% of all grain entrapments in 2016 involved children and youth under the age of 21.

- OSHA Region 5 and 7 have accounted for 68% of all documented agricultural confined space-related incidents.

Project Website

With support from a Susan Harwood Grant from the U.S. Department of Labor, a unique website was developed (www.agconfinedspaces.org). The purpose of this site was to provide resources for those conducting safety and health training in the area of agricultural confined spaces, with a special focus on grain storage and handling hazards. Training resources, frequently asked questions, past summaries of injuries and fatalities and an extensive bibliography can be found at the site. Since it was put online in 2013, it has hosted over 8,500 visitors.

One of the most frequently visited resource on the website is the curriculum developed for young and beginning workers in the grain industry (called Against the Grain). The goal of this teaching resource is to provide agricultural and safety educators with an evidence based 3-5 hour training program to present basic awareness safety and health training to youth, ages 16-21, who are employed in grain handling and storage facilities. The curriculum has been delivered to over 4000 youth in both secondary school agricultural education programs and informal, out-of-school settings. Pre- and post-testing have demonstrated a significant knowledge gain and instructor feedback has been very positive. The complete curriculum is available as a free download.

The second education resource at the site is designed for use in training emergency first responders to safely respond to incidents at grain storage and handling facilities. Over the past five years over 3000 emergency first responders have participated in training using this material.

Published Works

As the result of the analysis of the data gathered over the past five years, the following articles have been published. Full text for some of these articles are available at www.agconfinedspaces.org.

Roberts, M. J. Field, W. E., Maier, D. E., Stroshine, R. L. Determination of Effort Required to Insert a Rescue Tube into Various Grain Types. ***Journal of Agricultural Safety and Health***, 18:4, 2012.

Riedel, S. M. & Field, W. E. Summation of the Frequency, Severity, and Primary Causative Factors Associated with Injuries and Fatalities Involving Confined Spaces in Agriculture. ***Journal of Agricultural Safety and Health***, *19*(2), 83-100, 2013.

Field, W. E., Heber, D. J., Riedel, S. M., Wettschurack, S. W., Roberts, M. J., Grafft, L. J. Worker Hazards Associated with the Use of Grain Vacuum Systems. ***Journal of Agricultural Safety and Health***, 20(3), 147-163, 2014.

Issa, S.F., Field, W.E., Hamm, K.E., Cheng, Y.H., Roberts, M.J., and Riedel, S.M. Summarization of Injury and Fatality Factors Involving Youth and Grain Entrapment or Engulfment in Agriculture. ***Journal of Agricultural Safety and Health***, 22(1), 13-32, 2016

Roberts, M. J. Field, W. E., Maier, D. E., Stroshine, R. L. Determination of Entrapment Victim Extrication Force with and without Use of a Grain Rescue Tube. ***Journal of Agricultural Safety and Health***, 21:2, 2015.

Issa, S.F., Cheng, Y.H., and Field, W.E. Summary of Agricultural Confined Space-related Cases: 1964-2013. ***Journal of Agricultural Safety and Health***, 22(1), 34-45, 2016.

Cheng, Y.H. and W.E. Field. Summary of Auger-related Entanglements Occurring Inside Agricultural Confined Spaces. ***Journal of Agricultural Safety and Health***. 22:2, 2016.

Issa, S.F., Field, W.E, Schwab, C.V., Issa, F.S. and Nauman, E. Contributing Causes of Injury or Death in Grain Entrapment, Engulfment and Extrication. ***Journal of Agromedicine***, 22:2, 2017.

Issa, S.F. and Field, W.E. Determining the Pull-Forces Required to Extricate a Victim Entrapped at Various Angles in a Grain Mass. ***Safety***, Accepted for publication, 2017.

In addition, the following papers have been submitted for publication and awaiting peer review.

Cheng, Y.H., Field, W.E., Tormoehlen, R.L., and French, B. Utilizing Secondary Agricultural Education Programs to Deliver a Grain safety Training for Young and Beginner Workers. Submitted to Journal of Agromedicine

Issa, S.F. and Field, W.E. Grain Entrapments and the Harness: A Review on the Effectiveness of the Harness as a Safety Device. Submitted to Journal of Agricultural Safety and Health.

Issa, S.F., Nauman, E., Wassgren, C., Schwab, C.V., Ahsan, Z.S., and Field, W.E. Measured Spine Tensile Force Limits for Extracting Grain Entrapped Victim. Submitted to Journal of Safety.

For additional information on this report, contact Professor Bill Field at 765-494-1191 or field@purdue.edu. In addition, refer to these sources for more information on this topic:

- www.agconfinedspaces.org
- www.grainsafety.org
- www.grainentrapmentprevention.com
- http://apps.npr.org/buried-in-grain/