

## **2012 Summary of Grain Entrapments in the United States**

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Since 1978, Purdue University's Agricultural Safety & Health Program has been documenting agricultural confined space incidents<sup>1</sup> throughout the United States. Approximately 1500 cases have been documented and entered into Purdue's Agriculture Confined Spaces Incident Database (PACSID), with the earliest case dating back to 1964. Figure 1 provides a comparison of all documented cases with respect to type of incident. As can be seen, those cases involving the storage, handling, processing, and transport of grain account for the overwhelming majority of documented confined space-related cases, with over 1,050. The majority of these cases involve entrapment<sup>2</sup> or engulfment in free flowing agricultural materials, primarily grain. Other, less frequent relevant events include, machinery entanglement inside a grain storage structure, fall into or from a grain storage structure or asphyxiation due to a toxic atmosphere inside a grain storage structure. It is known that due to less aggressive surveillance efforts, incidents involving manure storage and forage silos are significantly under reported. This article focuses on documented grain storage and handling cases documented during 2012 with observations concerning the frequency and nature of these events.

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<sup>1</sup> An incident may involve multiple victims that are recorded in the database as individual cases.

<sup>2</sup> Flowing grain entrapments include both fatal engulfments and partial entrapments that required assistance in order for the victim to be extricated.

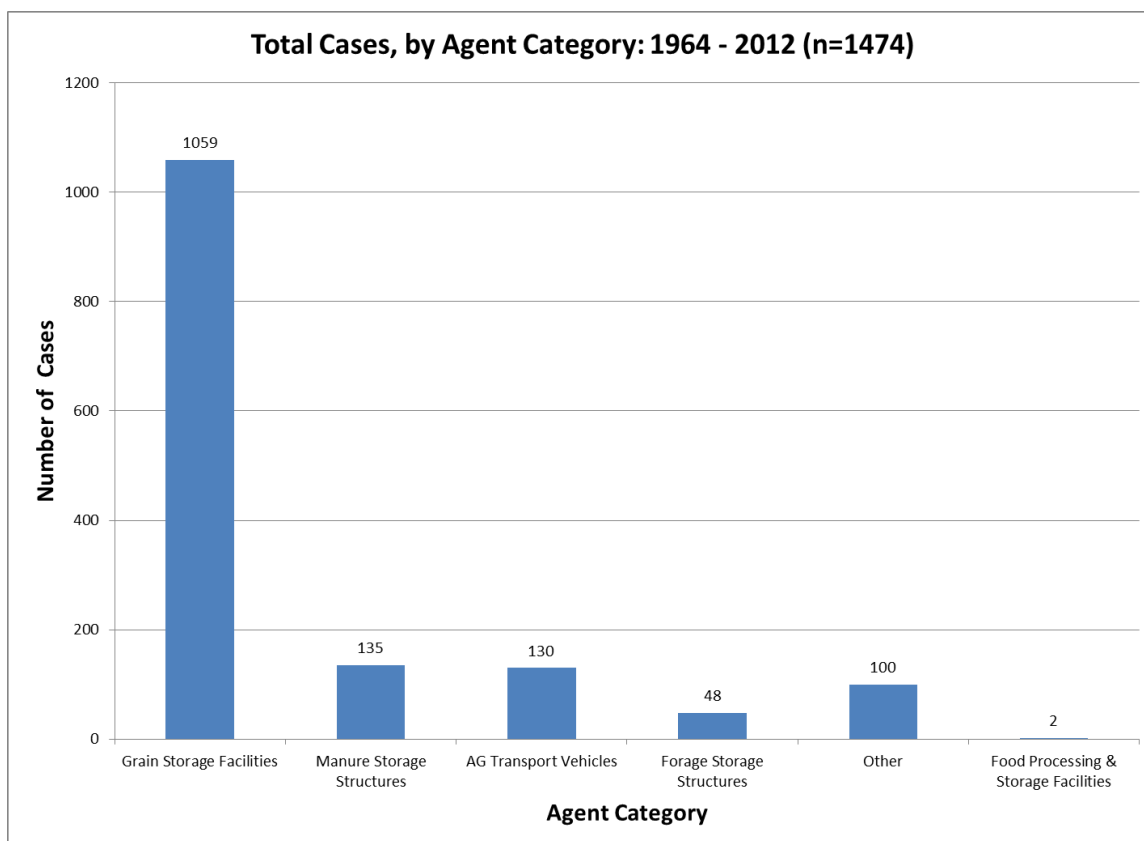


Figure 1: Agricultural confined space incidents from 1964-2012 based on agent category

Based upon the cases documented to date, no less than 19 grain entrapments occurred in 2012. This represents a 37% decrease in entrapments over 2011 when 30 entrapments were recorded. While this is not nearly the fewest number of entrapments ever documented, it is the least amount recorded since 1991 when no fewer than 17 entrapments were documented. The previous three years (2008, 2009 and 2010) experienced 33, 41 and 57<sup>3</sup> documented cases respectively. Due to increased publicity on grain entrapment cases and independent research conducted by National Public Radio (NPR)<sup>4</sup>, over 80 additional cases were entered in the database along with the 2012 cases. This increase caused the 2010 numbers to increase from 51 to 57 cases and other years also experienced a 1-2 case increase. This highlights the point that the PACSID is a fluid database that continues to be updated as new cases from previous years are documented and entered.

The trend for this type of incident, unlike many other types of farm-related injuries and fatalities, has been on the increase for the past ten years, as shown in Figure 2. Between 1997

<sup>3</sup> The 2011 summary of grain entrapments originally reported 51 cases, including several incidents with multiple victims. Due to continued surveillance efforts an additional six cases were documented and added to the database.

<sup>4</sup> NPR "Buried In Grain" Database for nearly 180 cases. <http://apps.npr.org/buried-in-grain/>

and 2002, the five-year average decreased from a then-record of 30.4 recorded entrapments per year to 23.0 in 2002 (the lowest since 1987). Since 2002, however, the five-year average has increased steadily back to an average of 29.8 incidents per year in 2008, 32.6 in 2009, and 37.6 in 2010 and peaking in 2011 with 38.6 cases. Although fewer entrapments took place in 2011 and 2012, the five year average still remains at 36.2 entrapments.

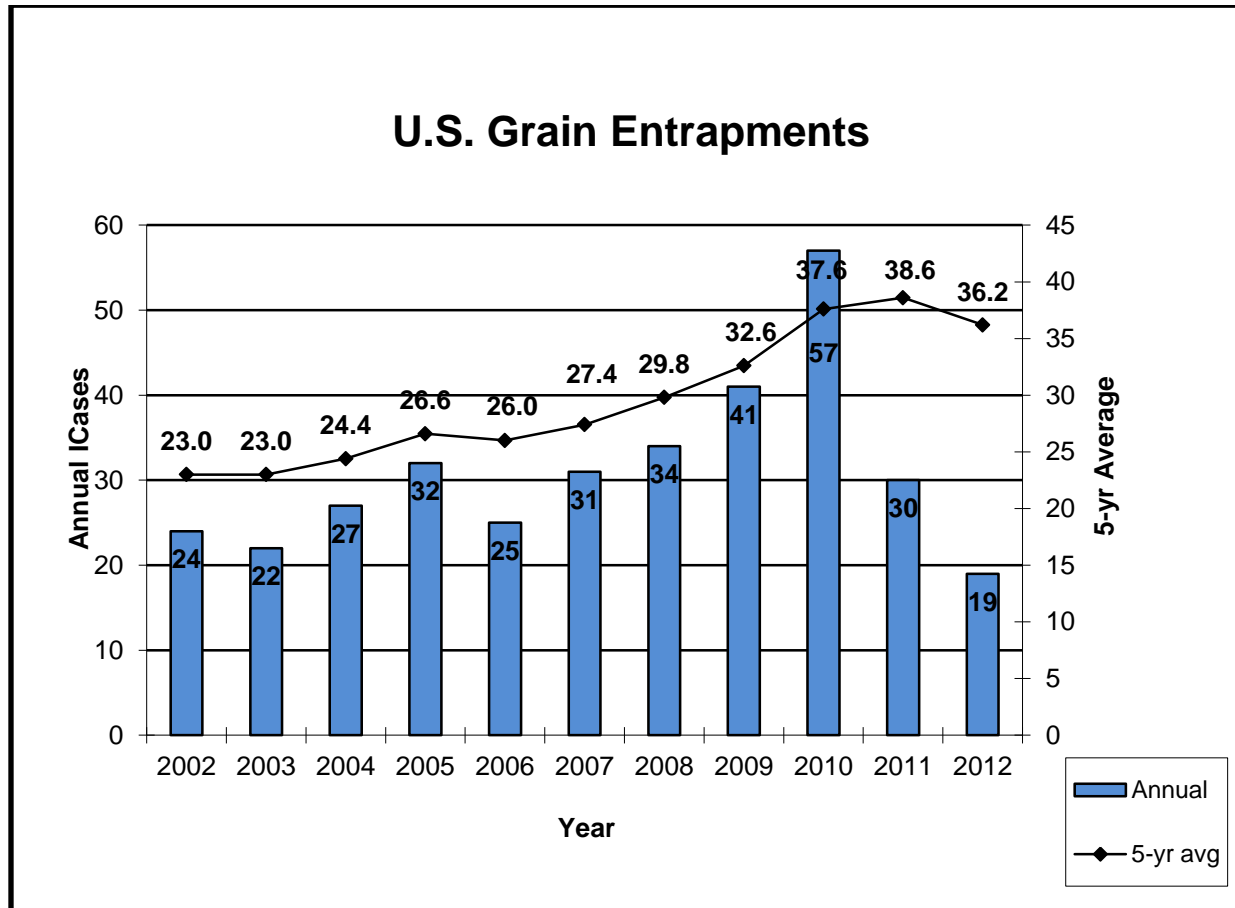


Figure 2: Number of annual grain entrapments recorded and the 5-year average between 2002 and 2012

As in past years, it should be noted that this summary does not reflect all grain-related entrapments that have occurred, fatal or non-fatal, due to the lack of a comprehensive reporting system and a continued reluctance on the part of some victims and employers to report partial entrapments where extrication was required but no public report of the incident was made. Furthermore, comparison between the number of farms with grain storage capacity by state with the number of incidents shows a very strong correlation for all states with the exception of Indiana. Indiana has documented nearly 3 times the cases it is supposed to have if it followed the

trend line (32% of 2012 cases). This is, as noted, probably due to the more vigorous effort in collecting all fatal and non-fatal cases in Indiana over the past 30 years. If all other states had collected incident data with the same level of intensity as Indiana and the findings had followed the Indiana trend line, one would expect more than a 100% increase in documented cases (Figure 3).

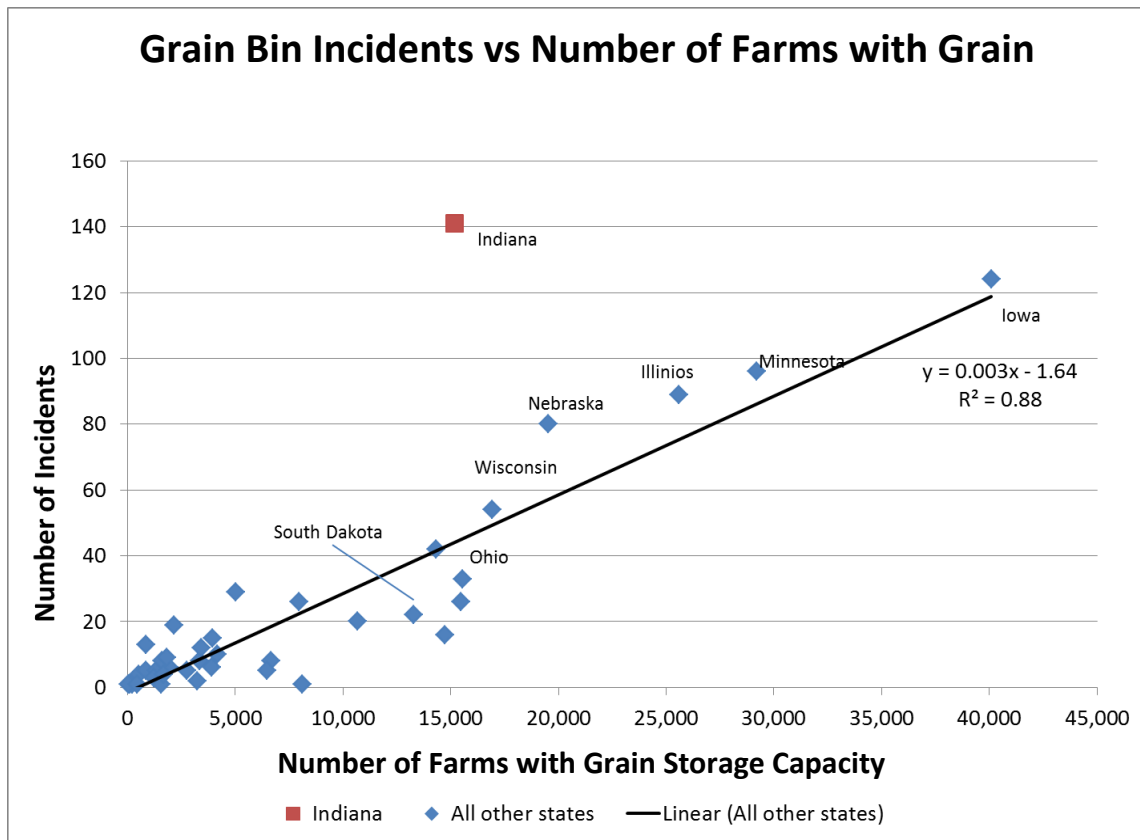


Figure 3: Grain bin incidents from 1964-2012 for all US states compared against number of farms with grain storage capacity in each state according to NASS 2007 Census data

In 2012, the states with the most documented grain entrapments, fatal and non-fatal, were Indiana (6), Arkansas (3) and Minnesota (2). Overall, entrapments were documented in 10 states in 2012. Figure 4 provides a geographic distribution of documented incidents where the location was known. Again, it appears that both Indiana and Arkansas reflect either more aggressive surveillance or a statistical outlier. Arkansas has historically reported very few cases.

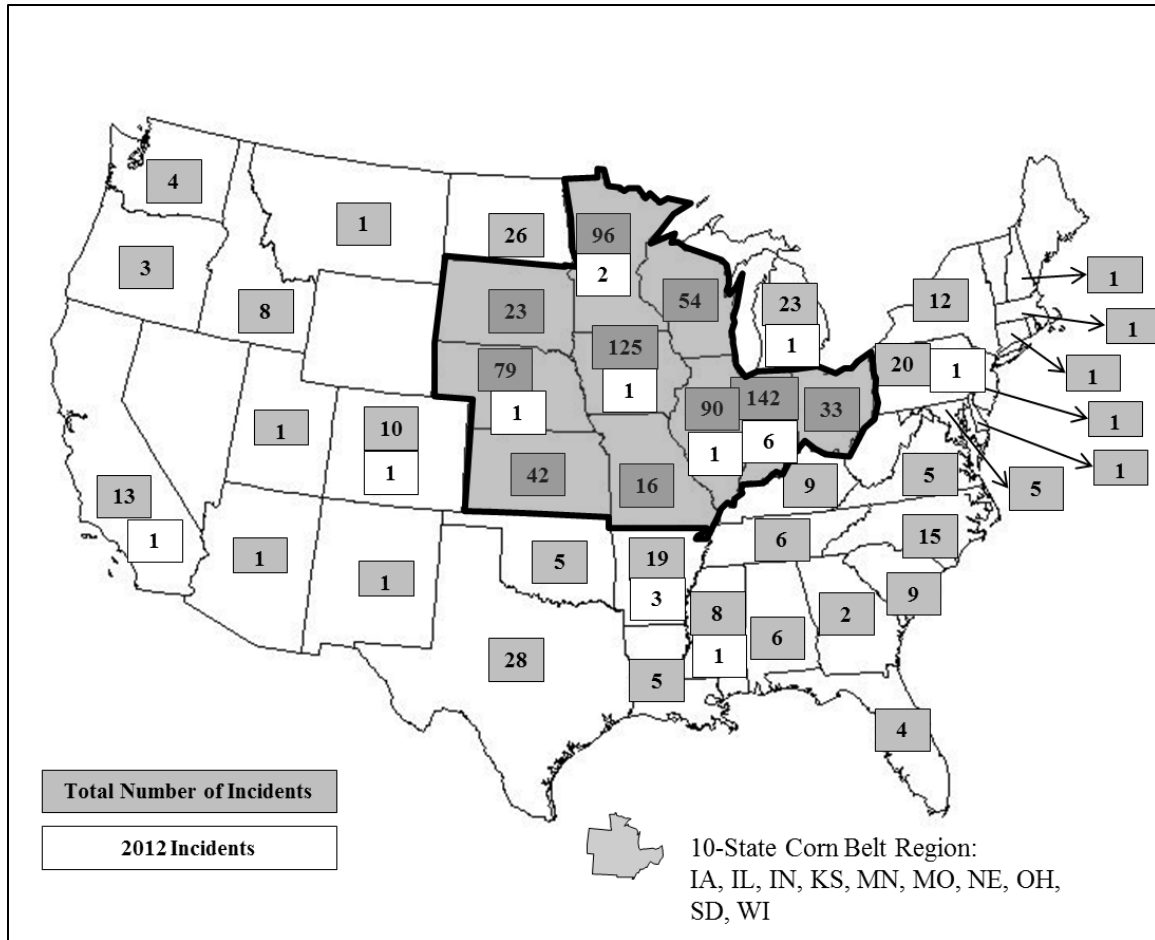


Figure 4: Distribution of grain entrapment cases across the United States. Case numbers in white boxes (below gray boxes) are for 2012 data only

Historically, approximately 70% of all documented entrapments, where the type of work site was known, have occurred on farms or other locations currently exempt from the OSHA Grain Handling Facilities Standards (29 CFR 1910.272) with the balance taking place at commercial grain facilities. In 2012, however, the percentage of entrapments that took place on exempt farms was less than those that occurred at commercial facilities. In 2012, of the entrapments where the incident location was known, 7 (37%) entrapments occurred on exempt farms and 9 (47%) entrapments were at commercial facilities; there were 3 cases (16%) where the entrapment location type could not be determined with the available data. All documented victims were male.

In 2012 there was one incident involving a youth under the age of 16, as shown in Figure 5. This entrapment took place at a farm location currently exempt from the OSHA Grain Handling Facilities Standard. Overall, a specific age was known for 9 of the 29 victims in 2012, with the

oldest victim being 62, and the youngest nine years old. The average age was 38 years old, and the median age 33. All of the cases, where the age was unknown, appeared to be adult.

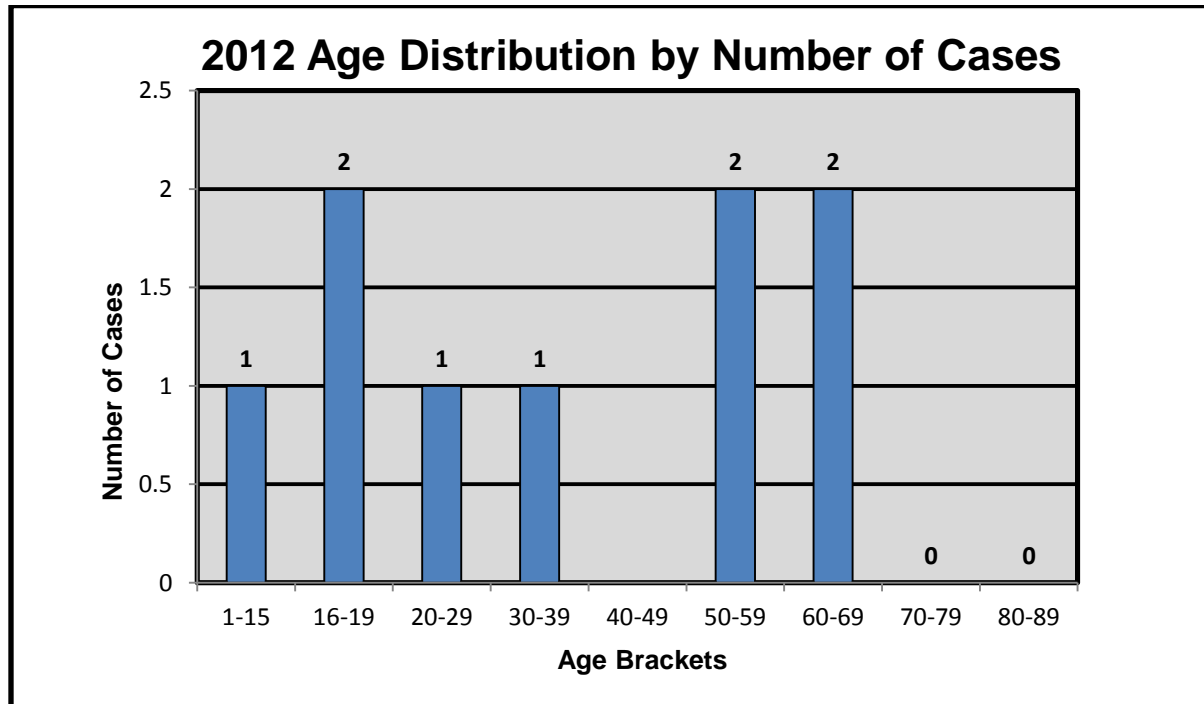


Figure 5: Age distribution of victims by number of incidents recorded

From 1964-2008, 74% of documented entrapments resulted in death. During 2009, 46% of the entrapments resulted in death with 55% of the entrapments in 2010 resulting in death, and 38% of cases resulting in death in 2011. In 2012 the ratio of fatal to non-fatal incidents increased to 42% of the entrapments resulting in death as shown in Figure 6. Overall, the slight decrease in the percentage of fatal cases is believed to be due to 1) more victims may be surviving these incidents due to increased emphasis on safer confined space entry procedures, 2) an increased emphasis on first responder training on grain entrapment extrication, and 3) increased public awareness of issues of grain entrapment and greater willingness to report non-fatal cases.

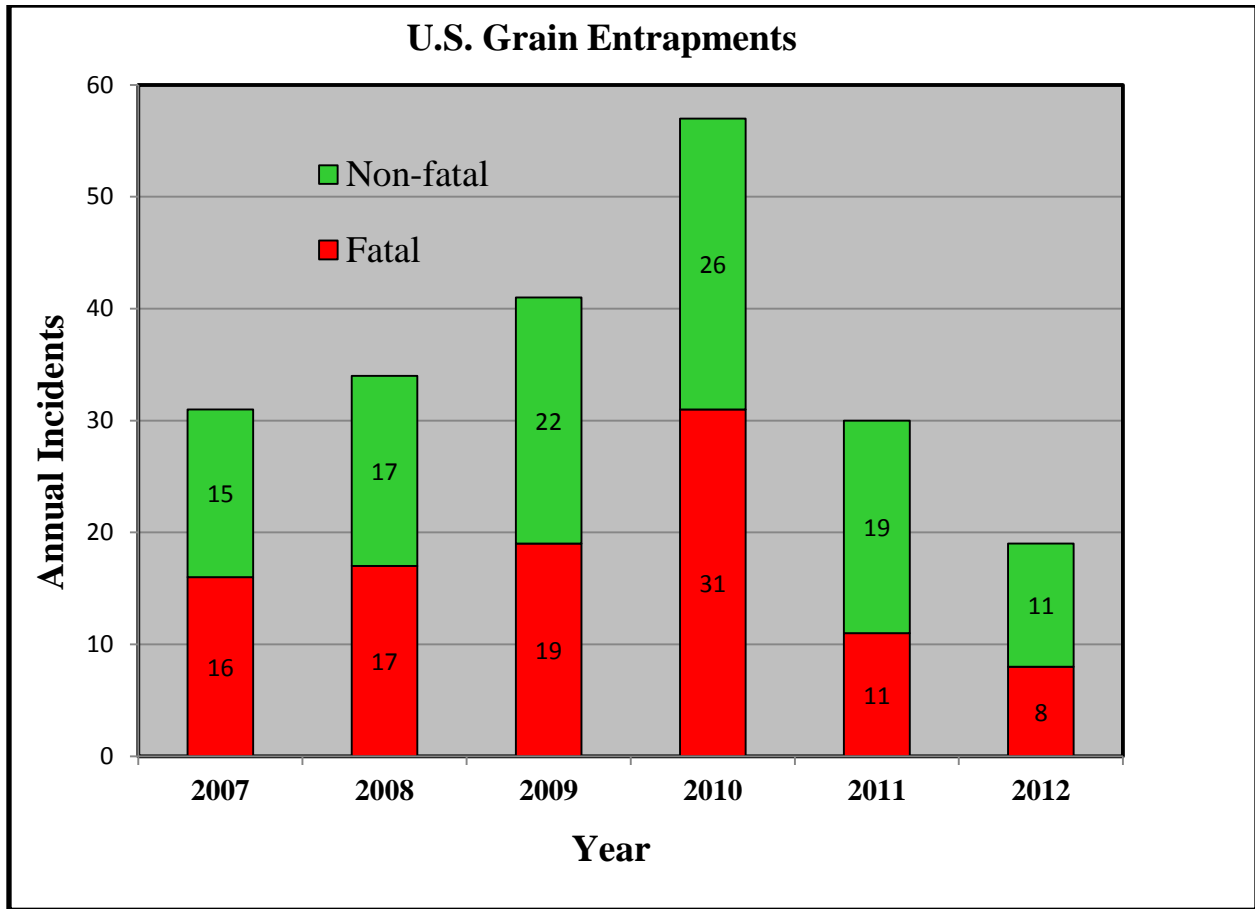


Figure 6: Fatal vs. non-fatal incidents recorded between 2007 and 2012

During 2012, the primary medium of entrapment, when identified, was soybeans (7 incidents, 37%). Corn followed soybeans as the primary medium of entrapment in 2012 with 4 incidents (21%). Over the past thirty years corn has been involved in approximately 45% of the grain-related entrapments where the medium was known. If further inquiry was conducted on the unknown cases, it is believed that the portion involving corn would be higher due to the volume produced and its tendency to spoil during long term storage. Other bulk materials that were documented in entrapments included processed feed, rice, wheat, and pinto beans.

The high quality of the 2011 crop reduced storage concerns and mitigated the amount of grain spoilage. This is why it is believed that when the 2011 crop was being pulled out of storage and marketed during 2012 there were fewer encounters with spoiled grain and thus fewer

entrapments for 2012<sup>5</sup>. In comparison, the 2009 crop<sup>6</sup> had exceptionally high moisture contents that resulted in more reports of out-of-condition or spoiled grain in storage and increased incidents of plugged flow of the stored crop being shipped in 2010. The poor condition of the 2009 crop was most likely the most significant contributor to the record entrapment numbers that were recorded in 2010.

### Iowa vs Indiana Case Study

Iowa and Indiana are two states with the highest number of previously documented grain entrapment incidents. In addition, Iowa represents the largest producer of corn (~2,400 million bushels) and Indiana represents the 5<sup>th</sup> largest producer of corn (~ 800 million bushels). Since the agricultural confined spaces incident surveillance project is located at Purdue University, in Indiana, it is expected that Indiana would account for a larger number of documented cases. The comparison illustrated in Figure 7 compares the frequency of documented cases for Indiana and Iowa over time (decade intervals).

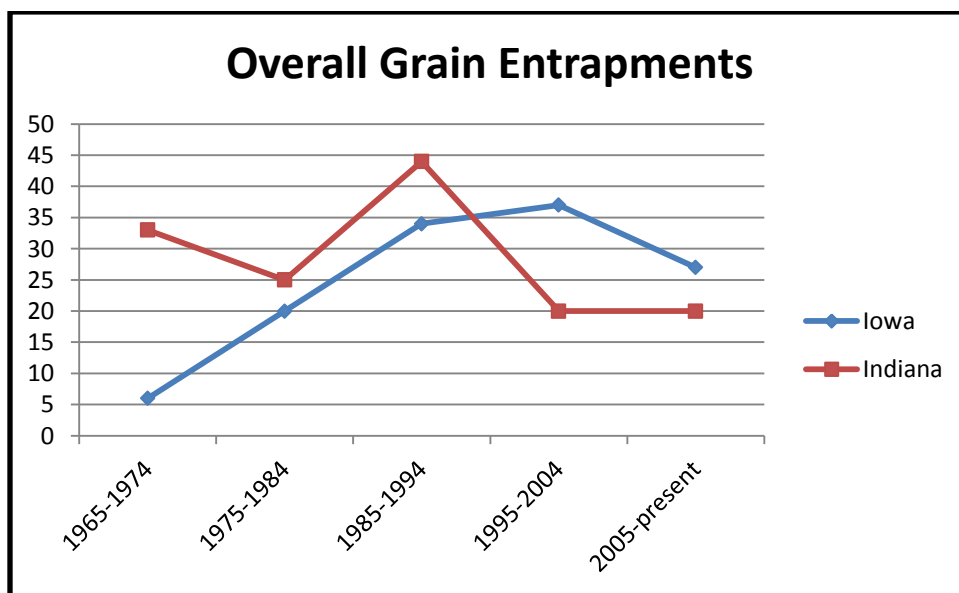


Figure 7: Overall entrapment cases for Indiana and Iowa over a 40 year period

<sup>5</sup> Kingman (2003) found a direct correlation between out-of-condition grain and an increased probability of entrapment.

<sup>6</sup> According to USDA, National Agricultural Statistics Service crop production data for 2009-2011, corn harvested in 2009 amounted to 13.11 billion bushels and soybeans harvested were 3.36 billion bushels. In 2010, corn harvested amounted to 12.45 billion bushels and soybeans harvested were 3.33 billion bushels. In 2011 corn harvested amounted to 12.36 billion bushels and soybeans harvested were 3.06 billion bushels.



In this comparison, Iowa started with a very low number of average annual cases (5) and gradually increased until it plateaued at 35 cases during the 1985-1994 decade (Figure 7). It seems that it will maintain the 35 average cases per decade during the last ten years (2005-2014). On the other hand, Indiana started with a very high number of cases (~35) and continued to fluctuate between 25 and 40. In the last two decades it has reached a plateau of nearly 20 to 25 average cases per decade. It is believed that the number of incidents, both fatal and non-fatal, documented in Iowa should be higher reflecting the greater number of farms with grain storage capacity and the volume of grain produced.

In terms of fatal versus non-fatal, initially both states start with more fatal cases than non-fatal cases. This trend continued until 2004. During the last decade, due to a variety of intervention efforts of non-quantifiable impact, a shift is seen in which there are more non-fatal than fatal cases in Indiana. While Iowa still has more fatal than non-fatal cases, the gap between them has diminished (Figure 8).

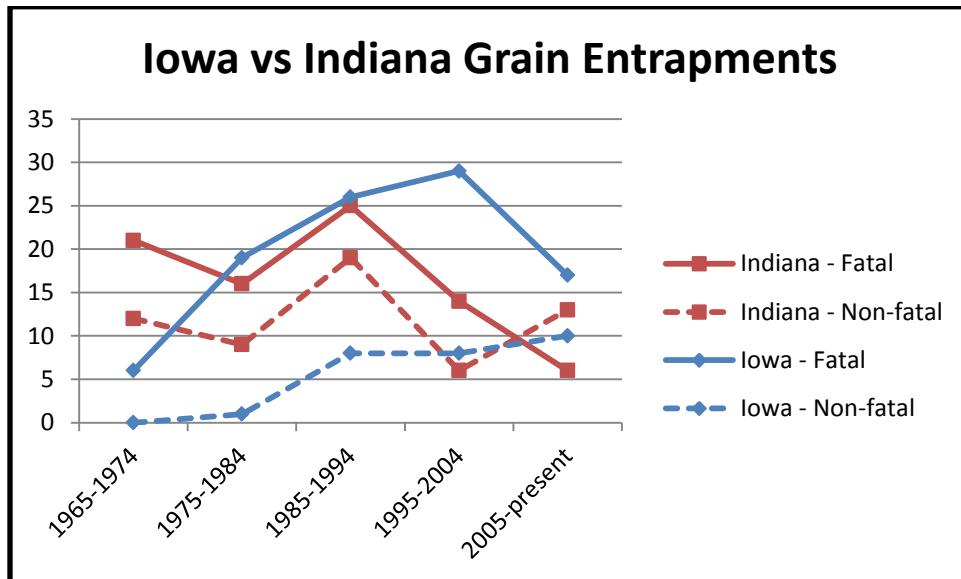


Figure 8: Entrapment cases for Indiana and Iowa over a 40 year period split by fatal vs non-fatal category

### General Observations

During the past year the topic of grain storage and handling safety has continued to be given unusual attention by various stakeholder groups including the commercial grain industry, OSHA, Land Grant Universities, farm and commodity organizations, and the general media. This

increased focus on grain entrapments has raised the issue to the national conscience. Continued effort in this field has a strong potential to bear fruit, foremost by the reduction in the frequency and severity of incidents, since they are 100% preventable. On-going research, targeted symposiums, development of new technologies and public dialogue involving all of the key stakeholders has increased the general understanding of the issues related to entrapments in grain and other free flowing agricultural material. This increased understanding is expected to result in a long-term reduction in the number of cases and a shift to where most of the cases are non-fatal. The 2012 data appears to be the beginning of this trend, however, these cases are strongly dependent on prevailing weather conditions (humidity, temperature) and long-term trends (5-10 year averages) which are a better indicator of grain entrapment trends.

For additional information on this topic check out

- [www.grainsafety.us](http://www.grainsafety.us)
- [www.grainentrapmnetnprevention.com](http://www.grainentrapmnetnprevention.com)
- <http://apps.npr.org/buried-in-grain/>

*Note: This summary was compiled by Salah Issa, Matt Roberts and Bill Field, Department of Agricultural & Biological Engineering, Purdue University. For additional information on grain entrapments, contact Bill Field at 765-494-1191.*

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