

## **2011 Summary of Grain Entrapments in the United States**

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Since 1978, Purdue University's Agricultural Safety & Health Program has been documenting grain entrapment<sup>1</sup> cases<sup>2</sup> throughout the United States. Over 900 fatal and non-fatal grain entrapment cases have been documented and entered into a National Agricultural Confined Spaced Incident Database, with the earliest case dating back to 1964. This article summarizes reported grain entrapment cases documented during 2011 with observations based upon available data. In addition, information is included on ongoing efforts at Purdue to assess the involvement of children and youth in flowing grain incidents, estimate the cost of compliance for currently OSHA exempt facilities, identify the potential hazards of grain vacuum systems, and develop new training resources.

Based upon the cases documented to date, no fewer than 27 fatal and non-fatal grain entrapments occurred in 2011 on farms and at commercial grain handling facilities. This represents a nearly 47% decrease in entrapments over 2010 when 51 entrapments were documented. While this is not the fewest number of entrapments ever documented, it is the least amount recorded since 2006 when 24 entrapments were identified. The 2011 total compared to 34, 38 and 51 cases documented during 2008, 2009 and 2010 respectively.

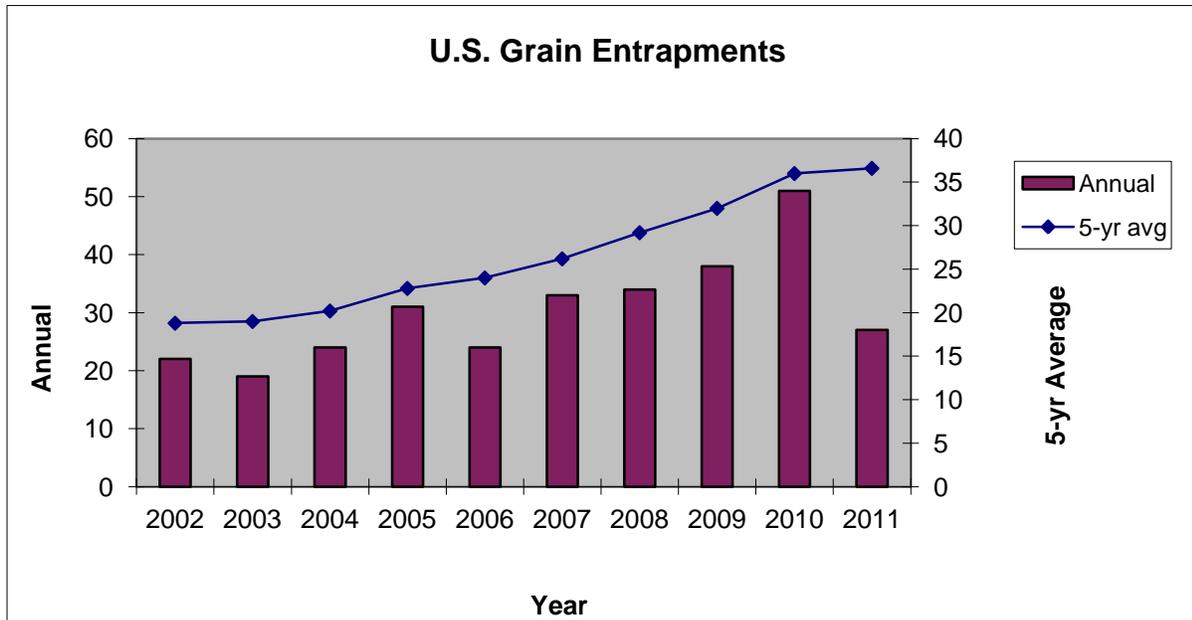
The trend for this type of incident, unlike many other types of agricultural-related injuries and fatalities, has been on the increase for the past ten years, as shown in Figure 1. Between 1994 and 2002, the five-year average decreased from a then-record of 29.2 recorded entrapments per year to 18.8 in 2002 (the lowest since 1987). Since 2002, however, the five-year average has increased steadily back to 29.2 incidents per year in 2008, 32.0 in 2009, and 36.0 in 2010.

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<sup>1</sup> Flowing grain entrapments include both fatal engulfments and partial entrapments that required assistance in order for the victim to be extricated.

<sup>2</sup> In some incidents more than one case of engulfment or entrapment may be reported. The number of cases reflects the number of individuals engulfed or entrapped.

Although there were nearly half as many entrapments in 2011 compared to 2010, the five year average still remains at 36.6. This is a jump in the five-year average of 12.5% from 2009 to 2011, and an increase of over 92% from the low point of 18.8 in 2002.



*Figure 1: Number of documented annual grain entrapments<sup>3</sup> and the 5-year average between 2002 and 2011.*

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 in the past year. Due to the lack of a comprehensive reporting system, exempt status of most grain storage and handling facilities to report injuries and a continued reluctance on the part of some victims and employers to report partial entrapments where extrication was required, it is believed the actual number is greater. Based upon the calculated ratio of non-fatal to fatal incidents documented in Indiana over the past 30 years, which has had an aggressive surveillance program to identify these events, the total number of actual cases could be 20-30% greater nationwide. It is believed that the number of documented fatalities represents a more accurate picture of reality than the number of non-fatal incidents.

In 2011, the states with the most grain documented entrapments, fatal and non-fatal, were Iowa (4), North Carolina (4), Illinois (2), South Dakota (2), Nebraska (2), North Dakota (2), and

<sup>3</sup> Data for 2006 was updated from previous reports to 24 incidents based on additional information and reports received. It was previously reported as 20 incidents. As new data is received, the database is updated which may change previously published summaries.

Texas (2). This geographic distribution parallels the long-term trend for these events to occur primarily in the Corn Belt. Overall, entrapments were documented in 15 states in 2011.

Historically, approximately 70% of all documented entrapments, where the site was known, have occurred on farms currently exempt from the OSHA Grain Handling Facilities standards (29 CFR 1910.272) with the balance taking place at commercial grain facilities. Beginning in 2007 and 2008 this distribution of cases changed substantially with 49% of documented cases occurring on exempt farms and 51% at non-exempt commercial sites. In 2009, where the location was known, 19 (63%) entrapments occurred on farms and 11 (37%) entrapments were at commercial facilities; the classification of the location was unknown for 8 incidents. This more historical trend continued in 2010, with 35 (69%) of the incidents occurring on exempt farms and 16 (31%) of the incidents occurring at commercial facilities<sup>4</sup>. In 2011, however, the percentage of entrapments on exempt farms and commercial facilities were nearly opposite of what had occurred in 2009 and 2010. In 2011, of the entrapments where the incident location was known, 7 (26%) entrapments occurred on farms and 15 (56%) entrapments were at commercial facilities; there were 5 cases where the entrapment location type could not be determined at the time of publication without additional investigation. All documented victims were male, and there continues to be a trend towards more managerial level employees / operators / owners being involved in entrapments.

In 2011 there was one incident involving a youth under the age of 18. This entrapment took place at a farm location currently exempt from the OSHA Grain Handling Facilities Standard (CFR.1910.272) and involved a high school student 16 years of age. Overall, age was known for 18 of the 27 incidents in 2011, with the oldest victim being 73, and the youngest sixteen years old. The average age was 41 years old, and the median age 45.

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<sup>4</sup> In the past, it was difficult to discern whether an incident occurred on an exempt farm or at a commercial facility due to incomplete reporting. In 2010, documentation allowed for a determination in each case.

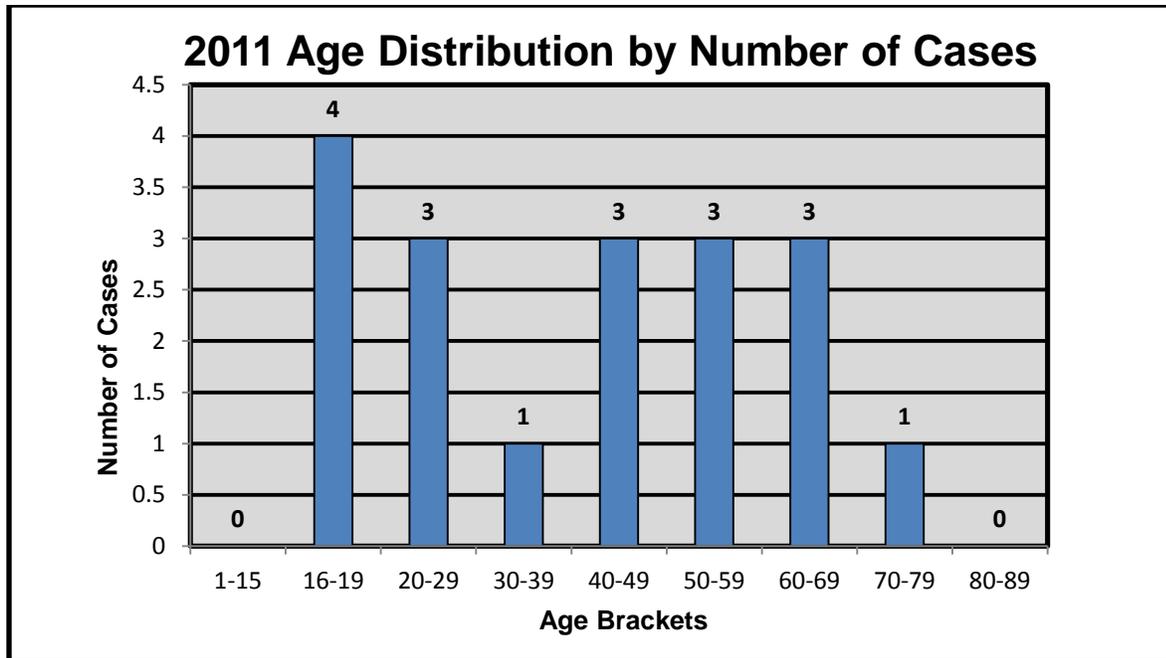
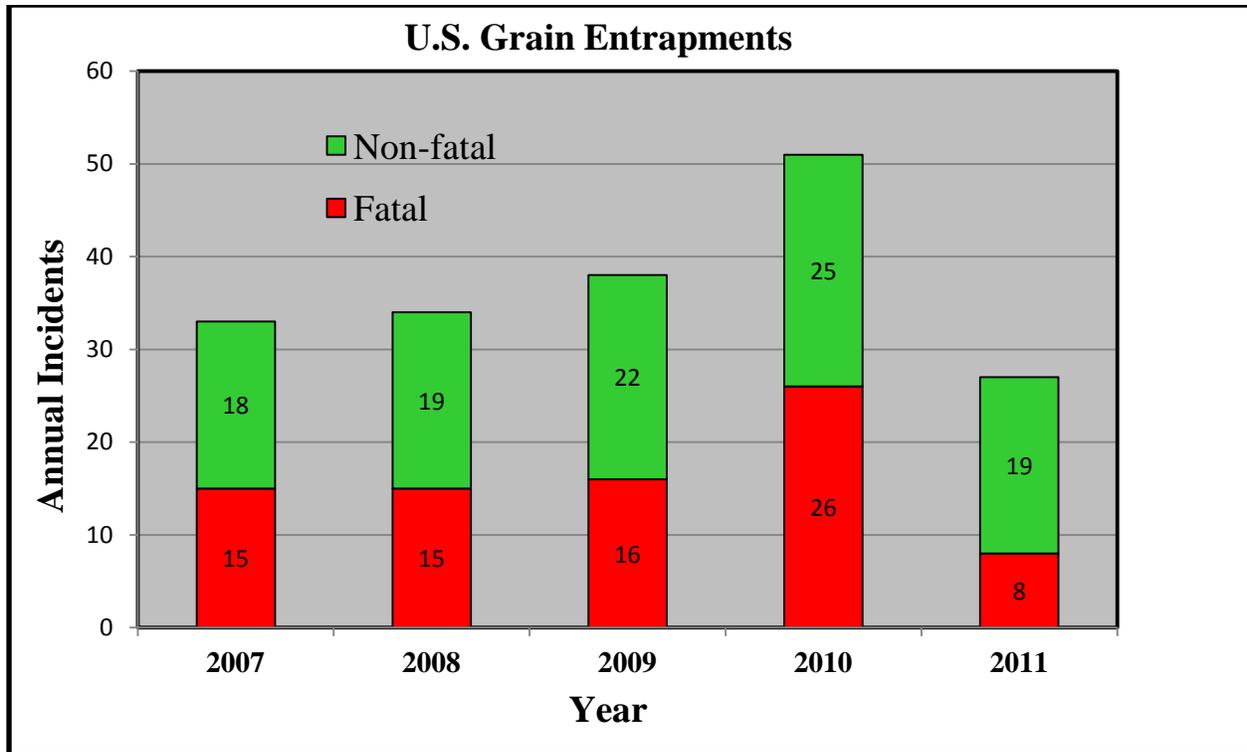


Figure 2: Age distribution of victims when known by number of incidents for 2011.

Due to the disproportionate number of youth under the age of 18<sup>5</sup> that have been historically involved in grain-related incidents, a study is underway to summarize all youth-related incidents currently documented in the database. Preliminary findings suggest that both the frequency and rate of this category of incident are on the increase when compared to other agricultural related workplace injuries and fatalities involving those under 18.

As shown in Figure 3, in 2011 the ratio of fatal to non-fatal incidents decreased when compared to earlier years. From 1964-2005, 74% of documented entrapments resulted in death. During 2008, 45% of the entrapments resulted in death with 42% of the entrapments in 2009 resulting in death, and 51% of cases resulting in death in 2010. In 2011 the ratio of fatal to non-fatal incidents decreased to 30% of the entrapments resulting in death. It is believed that more victims may be surviving these incidents due to increased emphasis on safer confined space entry procedures, such as using an observer during confined space entry, as well as an increased emphasis on first responder training on grain entrapment extrication techniques. At least three of the incidents documented in 2011 involved extrication using commercially available grain rescue tubes which were not widely available until 2007/2008. Two such cases were identified in 2010.

<sup>5</sup> It should be noted that under the current provisions of the Agricultural Hazard Occupations Order, the threshold for unrestricted employment in agriculture production is 16.



*Figure 3: Fatal vs. non fatal incidents between 2007 and 2011.*

During 2011, the primary medium of entrapment, when identified, remained yellow corn (17 incidents, 63%). 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. Other bulk materials that were documented in entrapments included processed feed, sorghum, silage, and cotton seed.

In 2011, the primary cause leading to entrapment of most victims was identified as entering a bin to loosen crusted, spoiled or frozen grain while unloading equipment was running (6 incidents, 22%). If further investigations were conducted on the remaining cases it is believed that this number would also be substantially higher. There continues to be a direct relationship between out-of-condition, or spoiled, grain and a greater probability of entrapment.

The 2009 crop was record in size and the subsequent 2010 and 2011 crops were not too far behind in the amount harvested<sup>6</sup>. The exceptionally high harvest moisture levels of corn and

<sup>6</sup> According to USDA, National Agricultural Statistics Service crop production data for 2009 and 2010, 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.

soybeans found in the 2009 crop resulted in more reports of out-of-condition or spoiled grain in storage and increased incidents of plugged flow during unloading of the stored crop going into 2010. The poor condition of the 2009 crop likely contributed to the significant entrapment numbers (51) that were recorded in 2010. In contrast, the 2010 and 2011 crops were somewhat smaller, of better quality, and came out of fields at lower moisture levels and higher test weights. As the 2010 crop was carried into 2011 there would have likely been fewer incidents of spoiled and crusted grain. This improvement in grain quality is seen as one of the primary reasons for fewer entrapments in 2011. It is also believed that the level of attention given to the problem of grain entrapment due to the record number of incidents in 2010 also contributed to greater awareness and reduced exposure.

Although there were fewer entrapments in 2011 compared to 2010, the five year average remains on the increase as shown in Figure 1. The domestic corn demand for ethanol has resulted in the largest build up of storage capacity across the Midwest in history. USDA estimated that in December of 2011, on-farm grain storage reached 12.5 billion bushels. These factors have resulted in more corn being stored for longer periods of time than in past years and possibly an increased potential for grains to go out of condition leading to another potential increase in grain entrapments unless there is a change in current work practices and design of grain storage and handling facilities.

## **Observations**

There exists a continuing need for an industry wide consensus on the importance of developing engineering safety design and practice standards for grain storage structures. Agricultural producers and commercial grain handlers should support an effort currently underway to draft engineering design standards for grain storage facilities that will be submitted to the American Society of Agricultural and Biological Engineers (ASABE) for consideration. In addition grain storage manufacturers should continue exploring ways to reduce the risk of removing residual grain and the problem of plugged flow, such as enhanced sweep auger designs.

Several of the commercial grain companies and grain bin manufacturers have increased their employee and farmer/customer education efforts to prevent grain entrapments from occurring. This has included new safety publications, safety messages in the farm and commercial grain industry media, and offering of training opportunities. During 2011 significant efforts were made

to increase the availability of grain safety related resources including the completion of a new grain safety DVD by the National Corn Growers Association and National Grain and Feed Association, development and promotion of new online resources: [www.grainsafety.us](http://www.grainsafety.us); [www.grainquality.org](http://www.grainquality.org); [www.ncga.com/videos](http://www.ncga.com/videos); and [www.grainentrapmentprevention.com](http://www.grainentrapmentprevention.com).

Significant developments have also been made on enhancing the capacity of rural emergency fire/rescue personnel and on-site first response teams to safely and effectively respond to grain entrapments. For example, Indiana has conducted approximately 60, 8-hour grain rescue classes for over 1,800 first responders from Indiana and surrounding states and has demonstrated grain handling safety practices at major regional farm shows, national commercial grain industry events, and fire/rescue conferences. Many other Corn Belt states are engaged in similar activities.

OSHA has also recognized the continuing problem of grain entrapments, particularly at commercial facilities. As shown in Table 1, OSHA has increased the frequency in which they have proposed fines for commercial facilities, where an entrapment had occurred, that were found to be non-compliant with the Grain Handling Facilities Standard (CFR .1910.272). In 2009 OSHA proposed fines for three facilities, in 2010 four facilities, and in 2011 nineteen facilities. From 2010 to 2011 there was nearly a fivefold increase in the number of fines OSHA had proposed. In many cases these fines were reduced through arbitration.

<b>Year</b>	<b>Month</b>	<b>OSHA Proposed Fine</b>	<b>State Location</b>
2009	Mar	\$109,000	TX
	Nov	\$1,600,000	CO
	Dec	\$121,000	NE
2010	May	\$1,600,000	SD
	Aug	\$374,000	WI
	Aug	\$721,000	WI
	Dec	\$75,000	KS
2011	Jan	\$623,000	IL
	Jan	\$729,000	IL
	Mar	\$64,000	NE
	Mar	\$466,000	OH
	Apr	\$378,000	SD
	May	\$188,000	TX
	May	\$60,000	MT
	Jun	\$167,000	IL
	Jun	\$79,000	NE

Year	Month	OSHA Proposed Fine	State Location
	Jun	\$123,000	MT
	Aug	\$186,000	NE
	Sep	\$62,000	CO
	Sep	\$229,000	MT
	Oct	\$258,000	TX
	Oct	\$57,000	TX
	Nov	\$155,000	NY
	Nov	\$127,000	NE
	Dec	\$95,000	SD
	Dec	\$132,000	NE

*Table 1: Proposed OSHA fines for grain facilities from 2009 to 2011.*

In addition, OSHA has made a significant commitment through the Susan Harwood Grant program to support projects to develop new teaching strategies and resources designed to reduce the frequency and severity of flowing grain related incidents.

The USDA has through the North Central Extension/Education Research Activity Committee has focused the last two years on developing a white paper to address research and educational needs related to confined space-related incidents in agriculture. This effort has been a catalyst for activities at several Land Grant Institutions, including plans for a national symposium on the topic.

**On-going Research Efforts**

Other ongoing efforts being conducted at Purdue to better understand the problem of grain-related entrapments include:

1. A study to explore the cost associated with bringing currently exempt grain storage and handling facilities into compliance with the applicable OSHA standards such as grain handling (29 CFR.1910.272) and confined space entry (29 CFR.1910.146). This is an extremely complex issue due to the inability of farmers to pass along the cost of compliance to the consumer of grain, the large number of aging facilities, and the lack of commercially available storage structures that meet current standards.

2. An in-depth look at the impact of grain related entrapments and engulfments on children and youth under the age of 18. Based upon current data, it appears that as many as one in five incidents involve younger workers or bystanders.
3. A summary of over 20 fatal and non-fatal entrapment incidents involving the use of grain vacuum machines is being completed. These incidents were largely unheard of until there was wide spread adoption of the technology over the past few years.

### **Grain Dust Explosions**

Questions have been raised about the comparative risk of grain entrapment and engulfment and grain dust explosions which appear to receive greater public attention due to the catastrophic nature of dust explosions. The U.S. Department of Labor reported that between 1970 and 2010 there were approximately 600 reported/documented airborne grain dust explosions in commercial grain handling facilities. These incidents resulted in over 250 fatalities and over 1,000 injuries. During that same time period the number of documented fatalities from engulfment in grain was more than twice the number of fatalities resulting from explosions. However, the number of documented injuries due to grain entrapment was less. Engulfments tend to involve only one, and in rare cases two victims, while explosions can involve larger numbers of workers who are burned or injured by the explosion.

### **Summary**

Every flowing grain entrapment is a preventable incident. The recent near record crop for 2011, much of it that went into storage in good condition, should be a reason to celebrate and not the cause for tragedy and sorrow. The grain entrapment problem can be addressed through the use of appropriately designed and maintained storage facilities, proper grain storage practices, proper use of personal protective equipment, implementation of safe work practices and having in place effective emergency response capabilities.

### **For More Information**

For additional information concerning this report contact Professor Bill Field at Purdue University. He can be reached at 765-494-1191 for [field@purdue.edu](mailto:field@purdue.edu). If you have personal knowledge of an entrapment in grain, we would appreciate hearing from you.