

TO: Director, National Institute for Occupational Safety and Health

FROM: Iowa FACE Program

SUBJECT: Farmwife was killed as a gravity flow wagon filled with beans tipped over on her.

SUMMARY

In October 1998, a 50-year-old Iowa farmwife was killed when a grain wagon tipped over on its side, crushing her underneath. The wagon was filled with soybeans and was being pulled in from the field. While going through a shallow ditch, the wagon slightly tipped to the right and a few bushels¹ of beans spilled onto the ground. The wagon's grain box had shifted back 120-150 mm (5-6") and fallen from its support on the running gear, causing it to tilt to the right (relative to the direction of travel). The farmwife stopped and left the wagon in this location overnight as further pulling could have worsened the situation. The next morning the farmer and his wife planned to empty the tilted wagon and then lift the grain box back in its proper position. They took an auger and another wagon to the field and began transferring grain from the tilted wagon when it suddenly tipped over on its right side. The grain box was secured to the running gear with chains at two opposite corners, leaving the other corners unattached. This compromised the stability of the wagon and the box tipped over unexpectedly when about one sixth of the beans had been removed. The wife was shoveling up spilled beans on the ground next to the wagon and was instantly pinned under the side of the falling grain box. The farmer tried to dig her out from under the grain, but being unable to do so, summoned for help. Rescue personnel used air bags to lift the wagon, but the woman had died from asphyxiation under the grain box.

RECOMMENDATIONS based on our investigation are as follows:

#1: *Gravity flow wagon manufacturers, dealers, and owners should ensure that grain*

boxes are securely attached to the running gear at all four corners.

#2: *Farmers and users of gravity flow wagons should be made aware of the tipping hazard when unloading gravity flow wagons.*

INTRODUCTION

In October 1998, an Iowa farmwife was killed when a grain wagon tipped over on her. The Iowa FACE program became aware of the incident through local TV news and began an investigation. Information was initially gathered from newspapers and the County Sheriff, who provided excellent photographs. Two investigators visited the farm, interviewed the victim's husband, and examined an identical grain wagon and the running gear of the wagon that tipped

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over. The grain box itself was damaged and had been removed from the farm. The manufacturer's representative was interviewed by phone regarding technical details.

The farm had 170 acres in corn and soybeans. During the past two years they had discontinued beef cattle production. The farmer and his family had lived at that location for the past 24 years. This was a typical family farm, no formal safety program or safety training had been in place. The farmer was experienced with gravity flow wagons; he normally worked alone, occasionally receiving help from his wife.

INVESTIGATION

The wagon was four years old and had a capacity of 8.81 m³ (250 bushels); a full load of soybeans weighs 6,800 kg (15,000 lb)². The wagon had factory-made side wall extensions which increased its capacity to the dimensions above. The farmer had two identical wagons of this type and several older wagons. The grain was on the left side, direction of travel (See Picture 1).



The bottom of the box is asymmetric, slanted towards the side door. The top of the box is offset to the right side and overextends the right wheels (See Picture 2). According to the manufacturer, the wagon is designed so that the center of gravity is at the center line of the running gear with full load when side wall extensions are used. In this case the box was filled to the top with soybeans.

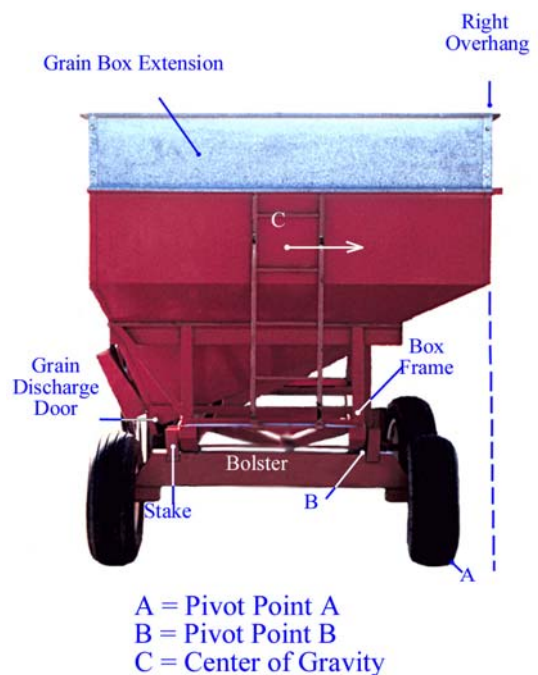
The farmwife was driving a tractor pulling the filled gravity flow wagon from the field to the farmstead. When going over a shallow drainage ditch in the field she noticed that

the box became tilted to the right and some beans spilled to the ground. Rather than risking more damage to the wagon and spilling more beans, she left the wagon there overnight. They decided to empty the wagon in the field before attempting to straighten the grain box. At 8:00 the next morning, they took another grain wagon and an auger to the field. Usually, unloading takes about twelve minutes. After a couple of minutes of unloading, the wagon box unexpectedly tipped to the right side. The front set of wheels tipped with the grain box while the rear wheels remained flat on the ground, separating from the box. The farmwife was kneeling on the ground to the right of the wagon scooping up spilled beans when the box tipped over. She was instantly pinned to the ground by the wagon and covered with beans. The farmer tried to dig her out, but realized he could not do it alone. He then drove to the farmhouse and summoned for help. Rescue personnel used air bags to lift the wagon, but the woman had died under the falling grain box.

Before they began unloading the wagon, it was leaning a few degrees to the right. While they were removing grain from the left side door, the center of gravity gradually shifted to the right. Since the box was not attached at all corners, the support base was narrow. The front point of support (pivot point) was the wheel's ground contact point but the rear pivot point was the bolster - box frame contact point (pivot point B). These two points formed the tipping axis.

The box frame stakes are 1,067 mm (42") apart, and the back pivot point therefore is only 533 mm (21") from the centerline of the running gear. This is narrow considering the height 2,616 mm (8'7") and width 2,235 mm (7'4") of the wagon. While unloading, the center of gravity shifted beyond the tipping axis and gravity pulled the grain box over. If the box had been attached at all four corners, the pivot point at the back would have been the wheel's ground contact point (pivot point A). This would have given the wagon

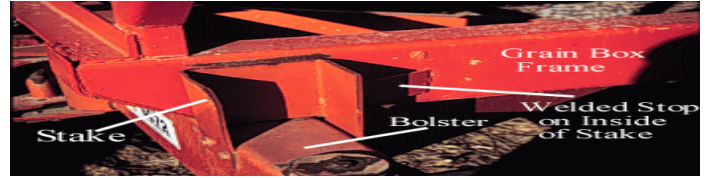
a wider support base. The wagon may still have tipped, but probably much later, and there may have been some visible or audible warning. These pivot points are illustrated in Picture 2.



The initial cause of the events was that the grain box moved back and fell from the bolster. According to the farmer this may have happened during transport to the field. At usual speeds, 16-18 km/h (10-11 mph), the empty grain box may bump and shift if not properly secured. Another possible cause is that the reach flexed during heavy pulling from the ditch and the right front corner of the running gear slid ahead from under the box stake. The third possible cause is that while the right front wheel hit a depression, the left back corner of the box was raised from the bolster enough so that the stops (tabs) on the box frame did not catch on the

stake as designed, but allowed the box to slide back on the running gear.

From Sheriff's photographs it appears the box had moved back before tipping. There was a depression on the bottom of the box frame about 150 mm ahead of the usual support position indicating that when tipping, the chain may have tightened and made this depression as the box tipped and the rear bolster stayed on the round. Whatever the actual chain of events, the inadequate attachment of the box to the running gear allowed the box to slide back and fall off the front bolster.



Picture 3 shows the box frame - stake connection. The sideways movement of the box is limited by the stakes on the bolsters. The length-wise movement is controlled by stops (tabs) welded to the sides of the box frames. These tabs are only on the inside of each stake. If the back tabs fail to stop the box from moving back, the front tabs will not help keep the box in place. The chain will stop the box, but since it is loose, it is not adequate to keep the box on the bolsters.

The front and rear bolsters are kept together by the reach – a steel pole 75 mm (3") in diameter, bolted to steel tube sleeves on the bolsters. This connection allows some flexibility. ASAE S360 determines a test standard for flexibility of the reach. It may be possible, although not likely, that the right front corner was pulled ahead 120-150 mm (5-6") from under the stop tab on the box frame. In some wagon models this is prevented by tabs on both sides of the stakes.

We examined the running gear during our visit. It appeared to be in good condition and suffered no obvious damage. Corner-to-corner measurements were identical indicating the running gear was square. All rubber tires were in good condition and tire pressures were not assumed to be a contributing factor. We were not able to observe how much play there was in the reach tubes due to the weight of the running gear. The reach is designed to keep the axles aligned but allow significant rotational motion. The two bolts holding the reach together were intact and appeared to be undamaged.

Based on our observation the main contributing factors leading to this injury were: inadequate mechanisms to prevent the grain box from sliding off the bolsters, narrow spacing between the stakes and narrow box frame, attaching the grain box only at two corners, the box being tilted and on slightly sloping ground while unloading, the factors determining the center of gravity (asymmetric shape of the box and heavy load), and removing grain from the left side shifting the center of gravity to the right. The grain wagon was not attached to a tractor at the time of the accident, however, attaching the wagon tongue would likely have little effect on the events. The weather was clear with slight frost on the ground. The noise from the auger and tractors may have prevented the farmer and his wife from hearing possible audible warnings from tightening chains or shifting metal parts.

CAUSE OF DEATH

The cause of death from the Medical Examiner's report was listed as: *positional asphyxiation*.

No autopsy was performed

RECOMMENDATIONS / DISCUSSION

Recommendation #1: *Gravity flow wagon manufacturers, dealers, and owners should ensure that grain boxes are securely attached to the running gear at all four corners.*

Discussion: In this case the grain box was attached to the running gear with two chains at two opposite corners. The result of this attachment was that the pivot point at the back was the box frame corner – running gear bolster contact point, which is only 533 mm (21”) from the running gear center line. This makes the support base of the wagon very narrow. The grain box tipped around this pivot point as the rear wheels stayed flat on the ground. Attaching the box from all corners would likely have prevented this fatal injury. Further engineering research may be needed to determine whether four corner attachment is feasible instead of currently typical two corner attachment. Based on this case, four corner attachment appears beneficial to prevent similar overturns and injuries. One technical solution can be as simple as attaching each corner with a chain.

In this case the grain box slid off the front bolster. The most likely reason was that when the right front wheel hit a depression, the back end of the box separated from the back bolster enough so that the tabs did not catch the stake, thus allowing the box to slide. In this wagon the tabs made contact with the stakes only on the inside of each stake. If the box raises about 150-180 mm from the bolster, the tab is too high and does not catch the stake. The box can simultaneously slide to the side enough so that the other side tab will not catch either, and the box can move back. A more reliable mechanism is needed to keep the box from sliding on the running gear. This can be as simple as welding larger tabs on the box frames --on both sides of the stakes. This can be done easily during manufacturing and can be added on later by the owners as well. Owners of these kind of wagons should be alerted about this potential hazard.

Recommendation #2: *Farmers and users of gravity flow wagons should be made aware of the tipping hazard when unloading gravity flow wagons.*

The farmer and his wife were unaware of the immediate danger when unloading the tilted wagon. The combination of the grain box falling off its support, the slightly sloping ground, the narrow base of support due to inadequately attached running gear, and the shifting center of gravity due to unloading from the left side caused the grain box to tip unexpectedly. Gravity flow wagons should be unloaded only on even ground. If the box has to be unloaded when it is tilted, careful precautions must be followed to avoid injury and tipping of the grain box or the wagon. Working near a damaged or tilted wagon should be avoided.

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References:

ASAE S239.1 DEC95. Hitch and box dimensions for agricultural grain wagons.

ASAE S360 DEC94. Test procedure for determining the load carrying ability of farm wagon running gear.

Units:

1 bushel (bu) = 35.24 liters (L)

Bulk density of soybeans is 60 lb/bu = 772 kg/m³

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