

MIFACE INVESTIGATION: #05MI123

SUBJECT: Truck Driver Dies When Straw Bales Fall Off Truck and Strike Him.

Summary

On November 3, 2005, a 62-year-old male truck driver died when straw bales he had delivered and was unloading fell from the truck trailer onto him. The decedent was contracted to haul a truck trailer loaded with 3- x 3- x 8-foot rectangular straw bales weighing 500-600 pounds apiece to a site 80 miles away. The bales had shifted during the trip from the originating farm to the purchasing farm (Figure 1). We postulate that after arriving at the delivery site, the decedent, beginning on the driver's side at the cab end of the trailer, removed each bale stack's ratchet binder. At the rear of the trailer, some of the stacked bales in the last



Figure 1. Trailer rear view, bales off trailer

row fell from the trailer to the ground after he removed this last ratchet binder. The purchasing farm's worker #1 transported some of the fallen bales from the rear of the trailer to the storage area. We postulate that the decedent, while standing on the passenger side of the trailer, began to roll up the securement straps. It appears that while rolling one of the straps, the decedent was struck by a falling bale. Worker #1 noticed that more bales had fallen to the ground. Because he could not see the decedent, he called for help. Another worker who arrived at the incident scene found the decedent under a bale on the ground. 911 was called. Another worker arrived and used a forklift to remove the bale from on top of the decedent. Emergency response arrived and the decedent was taken to a local hospital and where he was declared dead.

RECOMMENDATIONS

- Farm employers should develop a bale loading procedure to minimize the possibility of load shift and/or movement during transport.
- Farm employers should ensure cargo subject to motor vehicle cargo securement rules is appropriately secured in a manner to meet or exceed these requirements.
- Farm employers should develop a cargo securement assessment protocol upon arrival at the destination and develop unloading procedures specific to shifted loads, such as additional means of load support prior to unloading.
- Farm employers should ensure that all loads conform to the Michigan Motor Vehicle Code and Federal Motor Carrier Safety Act for cargo transport width and height requirements.

Key Words: Agriculture, Struck By, Load Securement, Straw Bales

INTRODUCTION

On November 3, 2005, a 62-year-old male truck driver was killed when the straw bales he was transporting fell from the trailer and struck him as he was in the process of removing the restraining straps. MIFACE was notified of this death by a newspaper clipping. On March 28, 2006, MIFACE investigators interviewed the decedent's employer. During the course of writing the report, the police report and pictures, medical examiner's report, and death certificate were reviewed. Figures 1, 3-6 are courtesy of the responding police department. MIFACE photographed the straw bale used in Figure 2. MIFACE modified the pictures used for Figures 1-6 to remove identifiers. Figures 7-9 were taken from the PowerPoint slide show from the Nevada Motor Transit Association website which includes the October 2004 Research and Test Report: Straw Bale Load Securement published by Innovative Vehicle Testing Ltd. Figure 14 was taken from Rural Industries Research and Development Corporation, Australian Government, Publication No 04/124, July 2004.

The decedent's employer, a farm owner, hired the decedent to haul straw bales from the farm location to a destination location. The farm owner contracted the decedent to provide straw bale hauling and delivery services. The decedent had provided these services for at least 10 years. The decedent was paid by the hour. The farm owner was the owner of the flatbed trailer. The farm owner stated that the decedent was a good worker and worked at a "full speed ahead" pace.

INVESTIGATION

Each bale was tied with four nylon strings. Figure 2 is a picture of a similar bale while in storage. The arrows in Figure 2 highlight the four nylon strings used to maintain bale integrity. The 3- x 3- x 8-foot straw bales had been baled in August 2005 and weighed approximately 500-600 pounds. The bales were loaded with a front-end loader equipped with a bale spear and secured on the trailer the evening prior to the decedent hauling and delivering the load. The trailer with the secured load was kept outside.



Figure 2. Nylon strings indicated by arrows around the hay bale

The following terms are used in this report: stack (bales directly on top of each other) and tier (each horizontal layer through the stacked material). There were a total of 72 straw bales on the trailer bed.

On the trailer deck were 15 stacks containing 4 tiers (60 bales). There were five rows of bale stacks; each row encompassed three bale stacks (12 bales). Four bale stacks with three tiers were located on the gooseneck (Figures 3-5). The forward most stacks on the gooseneck were double-strapped (Figure 3). It is unknown how the bale securement straps were applied on the bales for the trailer deck, how many 4-inch nylon securement straps/ratchets were utilized, and what the straps' working load limits were in this incident. The bales securement straps were tightened by hand.



Figure 3. Double-strapped bales on gooseneck, bales that fell from trailer deck

On the driver's side of the trailer deck it appears that each bale in the rearmost bale stack was loaded in a "flat" position, i.e., the plant stalk orientation was parallel to the ground. It is unknown how the remaining bales on the driver's side were loaded. The bottom bale of the middle stack at the rear of the trailer was also loaded in the flat position (Figures 1 and 6). The original orientation of the remaining bale on the passenger side at the rear of the trailer is unknown. This bale is in the vertical position, i.e., the plant stalks are perpendicular to the ground. This bale may have fallen from the middle stack, and the bale orientation may not be reflective of how it was loaded.

The decedent had driven the trailer approximately 80 miles on class A paved roads. It is unknown if he checked the load securement during his trip. The bales had shifted during the trip from the originating farm to the purchasing farm (Figures 1 and 6). When he arrived at the purchasing farm, the farm manager told him where to drive/park the truck so it could be unloaded. The decedent arrived at the unloading location, parked the



Figure 4. Straps on bales on gooseneck, rolled securement strap, open strap storage on cab

truck/trailer and began the removing the load securement devices. Worker #1 was instructed to help unload the bales from the trailer with a forklift. The police report stated that Worker #1 told the decedent not to take the middle strap off because the bales were leaning. The following sequence of events is postulated based upon police pictures, police report, and the interview with the decedent's employer. After arriving at the unloading site, the decedent, beginning on the driver's side at the cab end of the trailer, removed each bale stack's ratchet binder. At the rear of the trailer, some of the stacked bales in the last row fell from the trailer to the ground after he removed this last ratchet binder. According to the police report, when the decedent took the strap off the bales at the rear of the truck three bales fell to the ground. The police report does not indicate if any bales fell from the trailer as he released each ratchet binder or if the bale stacks remained intact, but leaning.

The bale striking the decedent was unwitnessed. It appears that the decedent, while standing on the passenger side of the trailer, began to roll up the securement straps (Figure 4), starting at the rear of the trailer. According to the decedent's employer, the decedent had rolled the straps for two or three rolls. Worker #1 transported some of the bales that fell from the rear of the trailer to the storage area. While he was at the storage area, he looked over toward the trailer and noticed that more bales had fallen to the ground. Because he could not see the decedent, he called for help. It appears that while rolling one of the straps, the decedent possibly with his back to the bales, was stuck by a falling bale(s). Another worker arrived at the incident scene and also called for help. A third worker arrived and picked the bales off of the decedent using a forklift. The decedent was found under a bale on the ground between the second and third row counting from the gooseneck (Figure 5). 911 was called and emergency response arrived. The decedent was transported to a local hospital where he was declared dead.

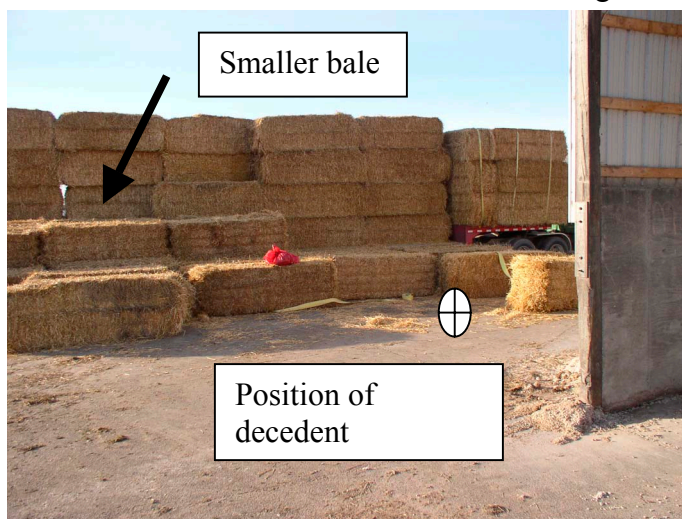


Figure 5. Illustration of variable sized bales and position of decedent

Figures 1 and 3-6 show the bale stacks on the driver's side of the trailer still intact, although leaning toward the passenger side (in the direction of the bales that fell). Several scenarios to explain the load shift were developed:

- The bales “racked” toward the passenger side. Racking refers to a bale content shift in one direction. During transport, straw and hay bales may have a tendency to rack, which causes a load to shift due to:
 - transportation vibration,
 - bale settling,
 - compromise of the bale edge through improper handling (e.g. rolling the bale),
 - non-uniform bale density,
 - different and/or irregular bale sizes in a stack (Figure 5), and/or
 - inadequate tiedown.

- One or more bales of the center stacks or passenger side stacks were loaded in the vertical position (i.e., vertical to the ground). This may have contributed to the bales “racking” toward the passenger side.
- Uneven bale drying. The exterior of the bale will dry before the interior, thus allowing for the bale edges to compress and the bale to become more “oval” in shape; the cut exterior sides become compressed by weight of bales above and pressure exerted by securement straps. Note in Figure 6 the driver’s side bale edge compared to the passenger side bale edge height). Bales can begin to “rock” back and forth due to the oval shape instead of sitting flat onto the trailer bed and each other.
- An insufficient number of tiedown restraining straps were used for the height, width, and weight of the load during transport.
- Transport speed, especially while making turns, may have contributed to the bales shifting.



Figure 6. Ovals to demonstrate compression on sides of bale

CAUSE OF DEATH:

As stated by the Medical Examiner on the death certificate, the cause of death was massive head trauma. Toxicology results were negative for alcohol and other screened drugs.

RECOMMENDATIONS/DISCUSSION

- Farmer employers should develop a bale loading procedure to minimize the possibility of load shift and/or movement during transport.

Rectangular bales may have an irregular shape due to how the bales weathered or if the baler settings were not properly adjusted. During baling, an irregular bale may be produced due to: (a) density differences (one side packed harder than the other side of the bale), or (b) improperly adjusted string knot setting (one bale side can expand more than the other side).

MIFACE encourages farm employers to develop a bale loading standard operating procedure (SOP) to minimize the possibility of bale shift during transport. An example rectangular hay bale loading procedure is attached as Appendix I. After development of these SOPs, farm employers should train employees, including those they may hire for contract or temporary work, and ensure that they understand the SOP and training received.

- Farm employers should ensure cargo subject to motor vehicle cargo securement rules is appropriately secured in a manner to meet or exceed these requirements.

The State of Michigan has adopted the Federal Motor Carrier Safety Administration’s (FMCSA) cargo securement rules. The cargo securement rules include all types of articles of cargo, except commodities in bulk that lack structure or fixed shape (e.g. liquids, gases, grain, liquid concrete, sand, gravel aggregates) and are transported in a tank, hopper, box or similar device that forms part of the structure of a commercial motor vehicle. Persons securing the load should be familiar with US Department of Transportation FMCSA load securement guide. The FMCSA Internet website includes links to both the FMCSA Cargo Securement Rules and Educational Materials Covering Cargo Securement. Internet Address: www.fmcsa.dot.gov/rules-regulations/truck/vehicle/cs.htm.

The cargo securement system used to restrain articles against movement must meet requirements concerning the minimum number of tiedowns, in addition to the rules concerning the minimum working load limit (WLL). General information about tiedown working load limits is contained in Appendix II. Without the use of longitudinal straps, FMCSA rules required at least two tiedowns per row. The bales were over 5 feet long but less than 10 feet in length (bales were eight feet in length) and each stack weighed at least 2,000 pounds (four bales at 500 pounds each). The bales on the gooseneck were not secured from forward movement, thus the requirement for two tiedowns per bale row (Figure 6). The bales were secured to the trailer with nylon tiedowns that went from an anchor point on the vehicle, over the cargo and then attached to another anchor point on the vehicle. The required working load limit for the tiedowns for each row, at minimum bale weights was 3,000 pounds.



Figure 7. Picture of typical V-board

The State of California offers an example of a securement system for similarly sized rectangular bales. The California Motor Vehicle Code has V-board (sometimes known as V-bar) construction and positioning requirements. The California Code requires that the V-board consist of two parallel pieces of lumber, metal, or other material not more than 12 feet in length, attached together near each end by flexible material (Figure 7). V-boards more than six feet in length shall also be attached at the approximate midpoint. The V-boards must be of sufficient length to restrain at least one-half of each bale to which they are applied. Materials used in the construction of

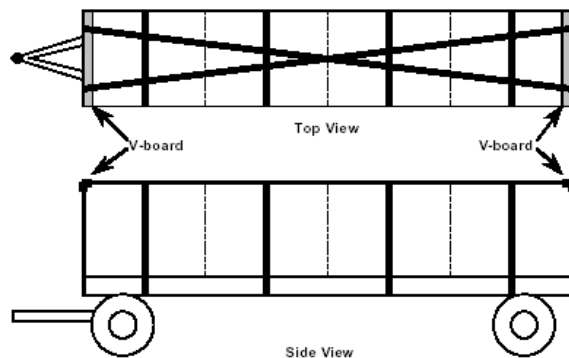


Figure 8. Picture of load securement example

V-boards shall be of strength not less than that of nominal size Douglas fir (1 inch by 3 inches). Lumber V-boards shall be free of strength-impairing knots. V-boards should be positioned at the top edge of the load (front/rear and/or sides) beneath the securement straps. Secure the load by at least two longitudinal securement straps that extend over the top of the load and V-board, attached from right front to left rear and left front to right rear so as to cross at the approximate top center of the load (Figure 8). In addition to the longitudinal binders, bale rows should be secured by one tiedown strap based upon the load characteristics.

A July 2004 report for the Rural Industries Research and Development Corporation in Australia found that the use of a diagonal bracing straps (tiedowns) provided improved load stability. The report recommended that diagonal bracing be considered for at least the front and rear groups of bales on a trailer, with the bracing pulling towards the center of the trailer. Figure 14



Figure 14 Diagonal bracing recommendations

was taken from the above referenced July 2004 report to illustrate examples of the recommended diagonal bracing. Make sure that the WLL of the tiedowns are compatible with the length and width of the load.

- Employers should develop a cargo securement assessment protocol upon arrival at the destination, develop unloading procedures specific to shifted loads during transportation, such as additional means of load support prior to unloading.

MIFACE recommends that employers develop and implement a standard operating procedure (SOP) for assessing the condition of the cargo prior to unloading, and SOPs for unloading procedures based on this assessment. Appendix III contains a sample SOP for stabilizing and unloading a shifted load to reduce the likelihood of a bale falling from a trailer and striking an individual unloading the trailer and train workers in this procedure.

MIFACE did not visit the unloading site. Generally, a trailer should be parked on a flat surface, even if the cargo does not appear to have shifted during transport. In this incident, if the trailer was parked on a slope (even a small slope), the slope could have contributed to the forces exerted on the shifted load, and could have contributed to the bales falling off of the trailer.

Bales have a friction coefficient between the bales themselves and the trailer deck. It is postulated that a factor in this incident was all of the tiedowns on the driver's side of this shifted load were loosened and/or removed, thus leaving no force applied to the other bales. This caused a decrease in the bale friction coefficient between the other stacked bales on the trailer deck. The decedent may have assumed that the load was "stable" because no additional bales fell after the rearmost bales fell. Although the load may have appeared "stable" after the rearmost bales fell, the loss of friction between the remaining bales may have contributed to the remaining bales falling.

- Employers should ensure that all loads conform to the Michigan Motor Vehicle Code for cargo transport width and height requirements.

Figures 1 and 6 show the bales on the driver's side of the trailer bed extend beyond the width of the trailer bed. Michigan Motor Vehicle Code, Section 257.717 allows agricultural commodities to be up to 108 inches wide but does not allow the outside width of the body of the vehicle hauling those commodities or the load on the vehicle to exceed 96 inches wide without a special permit issued by the jurisdictional authority. A jurisdictional authority means the state transportation department, a county road commission, or a local authority having jurisdiction of the highway the vehicle is traveling upon. Due to the friction coefficient of the bottom bale tier with the trailer bed, it is unlikely that the bales "slid" on the trailer bed.

The maximum height (from ground to top of load) allowed by the Michigan Motor Vehicle Code, Section 257.719 is 13 feet 6 inches. Although it appears that the trailer load height was above 13 feet 6 inches, with appropriate securement, the load height would not be a factor in this incident. Persons loading a vehicle should be aware of the 13-foot 6-inch height requirement because the Motor Vehicle Code stipulates that the owner of a vehicle that collides with a lawfully established bridge or viaduct is liable for all damage and injury resulting from a collision caused by the height of the vehicle, whether the clearance of the bridge or viaduct is posted or not.

RESOURCES

Michigan State Police, Motor Carrier Division. Michigan Farmers Transportation Guidebook 2006. Internet Address: www.michigan.gov/documents/Farm_Manual_2006_146760_7.pdf

Federal Motor Carrier Safety Administration. Internet website includes links to both the FMCSA Cargo Securement Rules and Educational Materials Covering Cargo Securement. Internet Address: www.fmcsa.dot.gov/rules-regulations/truck/vehicle/cs.htm

Nevada Motor Transport Association. Hay Cargo Securement link. Internet Address: http://www.nmta.com/index2.php?click1=hay_start

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Worksafe Victoria. Victorian WorkCover Authority Guidance Note: Hay and Silage Bales - Hazards of handling and transporting. June 2005. Internet Address: http://www.worksafe.vic.gov.au/wps/wcm/connect/WorkSafe/Home/Forms+and+Publications/Guidance+Notes/import_Hay+and+Silage+Bales+-+Hazards+of+handling+and+transporting

United Kingdom Health and Safety Executive: Safe Working with Bales in Agriculture. Leaflet INDG125 (rev2) Revised 06-06. Internet Address: <http://www.hse.gov.uk/pubns/indg125.pdf>

Occupational Safety and Health Service, New Zealand. Guidelines for the Safe Handling, Transportation, and Stacking of Large Hay Bales. Internet Address: www.osh.govt.nz/order/catalogue/pdf/haybales.pdf

State of Washington, Safety & Health Assessment & Research for Prevention, Washington Fatality Assessment and Control Evaluation. Fatal Facts: Hazards to Truck Drivers Loading and Unloading, April 30, 2005. Report #47-8-2005.
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California Office of Administrative Law (online source of California Code of Regulations). Barclay's California Code of Regulations. California Motor Vehicle Code. Article 2. Baled Hay and Straw – Loading, Securement and Transportation.
Internet Address: <http://government.westlaw.com/linkedslice/search/default.asp?RS=GVT1.0&VR=2.0&SP=CCR-1000&tempinfo=TOC>

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Appendix I

STANDARD OPERATING PROCEDURE FOR LOADING RECTANGULAR HAY BALES

- a. Ensure that the trailer loading area is as flat as possible.
- b. Park the vehicle, set the parking brake, turn the engine off, and remove the ignition keys.
- c. Check trailer for any significant damage that would impact load stability.
 - o A lip on the edge of the trailer deck will increase lateral load stability.
- d. Know where bales are unloaded and type of equipment available for unloading.
- e. Know the roadways to be used for transport.
 - o Additional tiedowns above the minimum number required may be needed.
 - o Rough roads, speed limit changes, and changes of direction (turns) may place additional forces on the load and straps
- f. The person responsible for loading should keep all persons who are not directly involved in the loading activity away from the work area.
- g. Evaluate bales prior to loading for the following characteristics:
 - o Density and Uniformity. Denser or larger bales should be used as foundation bales.
 - o Different Outside and Inside size. If different size bales are found:
 - Use cross-stack stabilizing devices such as boards or mid stack straps,
 - Place the larger bale side to the outside of the truck,
 - Interlock stacks where possible to reduce the lengths of bale interface, and/or
 - Place friction material between non-interlocked stacks.
- h. During the bale loading process:
 - o Determine if the load is greater than 96 inches wide. If greater than 96 inches, a special load permit is required.
 - o Load bales side to side generally on an equal basis. Overloading one side during the loading process can cause load shifting.
 - o Load bales in a flat position (bale contents parallel to the ground) whenever possible, interlocking them (change bale direction – for example, if first tier is North-South, place second tier in East-West direction) within layers and without space between each bale (Figure 9).



Figure 9. Example of interlocking bales

- i. Secure load with appropriate number of straps to meet Working Load Limit (WLL) requirements.
 - o Loads that are subject to racking or compression should be considered for additional tiedowns.
 - o Consider placing inter-tier crossing devices or straps (belly-strap). After all tiers are loaded, place tiedown over the top bale tier.
 - o Consider placing V-boards (Reference Figure 8) and two longitudinal straps running from the trailer deck's left front to the right rear and from the right front to the left rear, crossing in the middle. Run the straps over the V-boards placed along the top front and top rear edges of the load.
 - o Place lateral (side-to-side) tiedowns over the top bales in each row.
 - o If a special load permit is needed, consult the permit for any special or additional load securement required.
- j. Farm employers should instruct the persons hauling the load that the load and its securement must be checked every 50 miles.
 - o The in-transit load evaluation is important because the tension in the strap is generally higher at the tensioning device than at the anchored or hook end of the strap during the loading procedure because of the friction between the strap and the load.
 - o As the transport occurs the bales may settle and the strap tension may slowly decrease and need to be readjusted.

Appendix II

WORKING LOAD LIMIT – GENERAL INFORMATION

As a minimum, the Michigan Motor Vehicle Code requires that the aggregate WLL of any securement system (vehicle structure, securing devices, blocking and bracing equipment) used to secure an article or group of articles against side movement be at least one-half (50%) the weight of the article or group of articles. The aggregate WLL is the sum of:

- One-half (50%) the WLL of each tiedown that goes from an anchor point on the vehicle to an attachment point on an article of cargo; and
- The WLL for each tiedown that goes from an anchor point on the vehicle, through, over or around the cargo and then attaches to another anchor point on the vehicle.

NOTE: The WLL for front securement is 80%.

When an article of cargo is not blocked or positioned to prevent movement in the forward direction, the number of tiedowns needed depends on the length and weight of the articles.

- 5 feet or less in length and 1,100 pounds or less in weight: 1 tiedown
- 5 feet or less in length and more than 1,100 pounds in weight: 2 tiedowns
- Greater than 5 feet in length but less than 10 feet, regardless of weight: 2 tiedowns
- Greater than 10 feet in length: 2 tiedowns for the first 10 feet of length and 1 additional tiedown for every 10 feet of length or fraction thereof beyond the first 10 feet.

If an article is blocked, braced or immobilized to prevent movement in the forward direction by a headerboard, bulkhead, other articles that are adequately secured, or other appropriate means: at least 1 tiedown for every 10 feet of article length or fraction thereof.

The working load limit of a tiedown assembly is determined by:

- (a) The WLL of a tiedown, associated connector or attachment mechanism is the lowest working load limit of any of its components (including tensioner) or the WLL of the anchor points to which it is attached, whichever is less.
- (b) To determine the WLL use the tiedown manufacturer's markings or use the Working Load Limit tables in the FMCSA at §393.108. The WLL listed in the tables are to be used when the manufacturer does not mark WLL of the tiedown material. NOTE: Tiedown materials that are marked by the manufacturer with a WLL that differs from the FMCSA tables have a WLL equal to the value for which they are marked.

Appendix III

STANDARD OPERATING PROCEDURE FOR STABILIZING AND UNLOADING A SHIFTED LOAD

- a. Ensure that the trailer unloading area is as flat as possible.
- b. Park the vehicle, set the parking brake, turn the engine off and remove the ignition keys.
- c. The person dealing with securement should keep all persons who are not directly involved in the securement activity away from the work area.
- d. Determine if the load has shifted.
 - If an incline is present, ensure trailer is parked so shifted load is leaning uphill.
- e. If load has shifted, do not release tension on any tiedown ratchet until load is stabilized.
- f. Stabilize the load by using additional strapping. All bale rows should have additional strapping applied prior to any release of original strapping or unloading.
 - Re-apply binding straps in the same configuration to the load, with the binding strap securement to the “uphill” side of the shifted load.
 - Apply front to back straps or crossed straps that are connected clear of the bale row being unstrapped (Figure 8).
- g. After additional strapping has been applied, beginning on the rearmost bale row, release tension on the original ratchet side tiedown.
- h. With all personnel clear, remove the 2nd binding strap ratchet located on the uphill side on the rearmost bale row.
 - If the shifted load falls, it would most likely fall to the leaning side, not to the “uphill” side.
- i. If more than one tiedown is used for the bale row to be unloaded, follow steps f-h. :
 - Under no circumstances should both tiedown ratchets be loosened at the same time.
- j. After removing the tiedowns from the uphill side of the load, the bale unloading should proceed from the “stable” side (side opposite from the shift direction).
 - Unloading should be done using a forklift or other piece of equipment that has a SAE or ASAE certified falling object protection structure (FOPS).
 - The bales at the top of the stack should be removed first.
 - After this stack has been unloaded, again working from the stable side, the operator should begin to unload the next adjacent stack.
- k. After the rearmost stack row is unloaded from the trailer, begin unloading the next stack row following steps g-j.

MIFACE

Investigation Report # 05 MI 123

Evaluation

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Please rate the report using a scale of:

Excellent	Good	Fair	Poor
1	2	3	4

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1	2	3	4

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