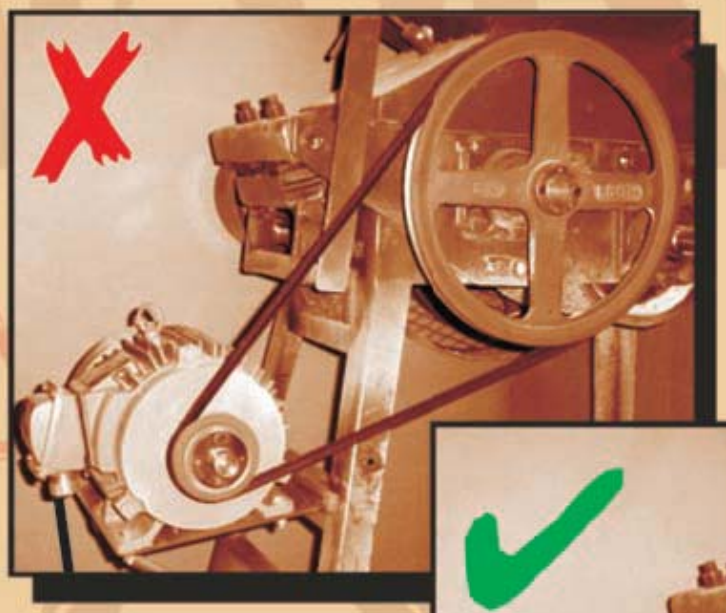
ON GUARD!

A Handbook for Home Built Guarding of Farm Equipment



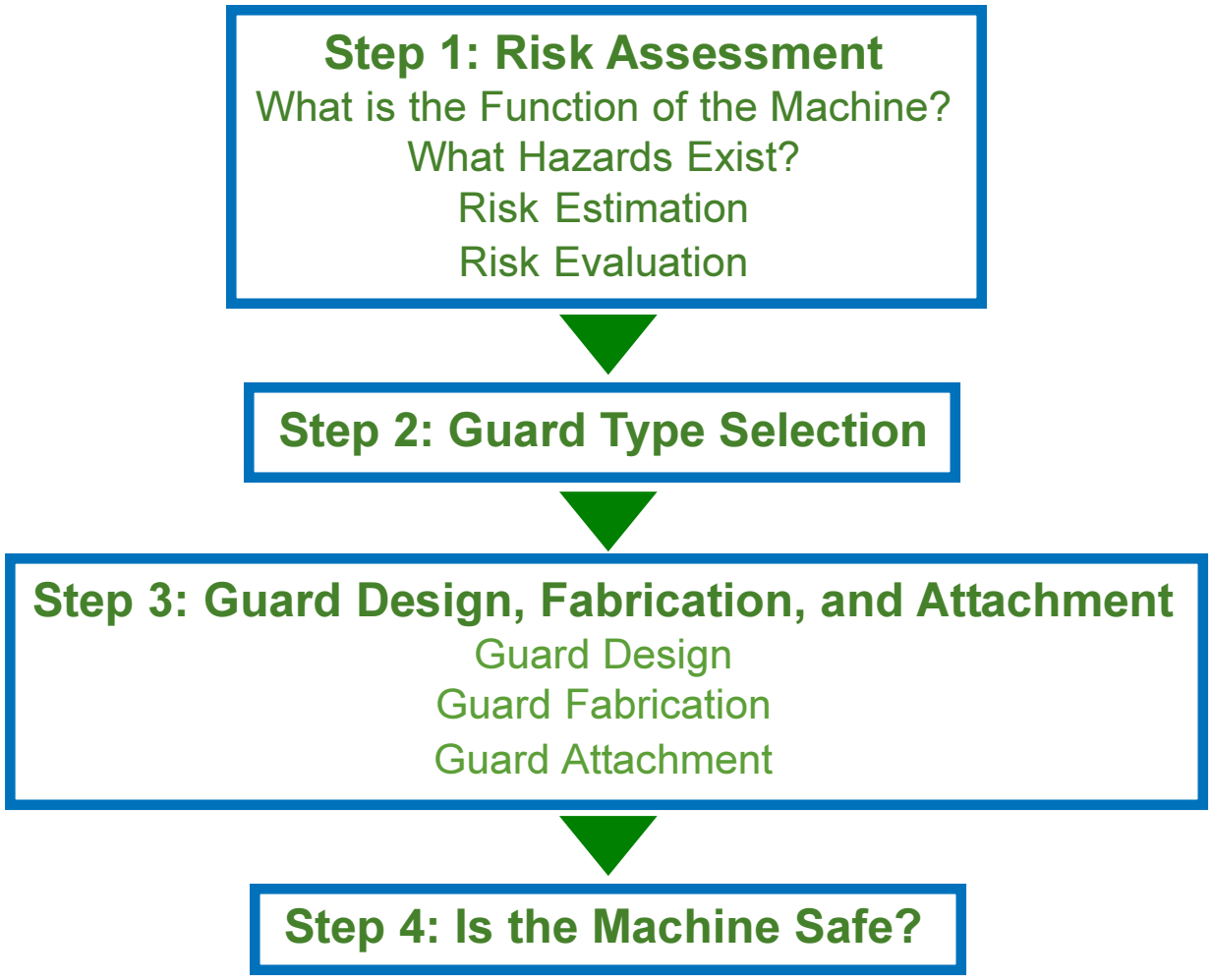
This Manual is one of the many projects to help achieve the vision of:

CASA·ACSA

Canadian Agricultural Safety Association
Association canadienne de sécurité agricole

"Safe and Healthy Agriculture in Canada."

Farm Machinery Guarding Procedure



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***NOTE:** The opinions expressed in this document are those of PAMI, and not necessarily the funders.*

Table of Contents

List of Appendices

1. Fast-Track User's Guide

The information in this handbook has been designed to help farm machinery owners and operators retrofit their used machinery with proper guarding. It does not replace or supersede any CSA, ASAE, OSHA, or ISO standards that are updated on a regular basis; nor is it a legal document to be used for law enforcement. Should you have any specific questions, your should consult with a Farm Safety Organization (see list of organizations on back cover of this publication), or other qualified people.

1.1 Introduction

Handbook Objective

This handbook was developed as a guide to assist and encourage farmers in the design and fabrication of guards for their farm machinery.

International standards organizations have established guarding requirements which are minimally acceptable and technically feasible for the safeguarding of new farm machinery. However, there are no standards dealing specifically with the guarding of used farm machinery. This guide aims to encourage farmers to safeguard their used machinery to adhere to the standards that govern new machinery.

Injury Statistics

There are over 1700 farm related, hospitalized injuries per year in Canada[1]. Farm machinery injuries cost the Canadian economy between $200 - $300 million annually[2]. Fatal injuries average cost was $275 000, permanent disability injuries average cost was $143 000, while the average cost of hospitalized injury was $10 000[2].

Over 850 of these injuries that are serious enough to be admitted to hospital are related to farm machinery. Almost one third of these injuries resulted from becoming entangled in the machinery. Most of these entanglement injuries could have been prevented if the machinery involved was guarded sufficiently. If this handbook prevents even one injury it has more than paid for the cost to develop and print it.

The injuries were caused by a combination of unguarded hazards and the person getting too close to the hazards.

PAMI Recommendation:
Always shut the engine or power off before servicing any part of machinery.

1. Canadian Agricultural Injury Surveillance Program (CAISP). Hospitalized Farm Injuries in Canada. 2000. and CAISP. Fatal Farm Injuries in Canada. 1998.

2. Locker, A.R., J.L. Dorland, L. Hartling, and W. Pickett. 2003. Economic Burden of Agricultural Machinery Injuries in Ontario, 1985 to 1996. Rural Health Research. 19 (3) 285-291

Definitions

Guard: A physical barrier that prevents access to a danger zone.

Danger Zone: The zone around the machine (front, back, sides, top, and bottom) where a hazard is created by the motion of the machine components

Hazard: A situation that may cause injury to a person.

Machinery: Apparatus for producing or applying power, having fixed or moving parts each with definite functions. This includes powered and non-powered machinery such as pulled implements. The term machinery also includes stationary equipment such as seed processing machinery and livestock handling equipment.

1.2 What Should be Guarded?

The guarding guidelines in this handbook have been sourced from CSA, ASAE, OSHA, and ISO standards. They apply to new farm machinery. This handbook will use these standards to guide the farmer in the design and fabrication of guards for their used machinery.

What should be guarded?

- Nip-points such as belt drives, chain drives, and gears.
- Outside faces of pulleys, sheaves, sprockets and gears.
- Revolving shafts, universal joints, PTO shafts, and other revolving parts with projections such as exposed bolts, keys, pins, or setscrews.
- Surfaces which create shearing or pinching hazards such as auger inlets.
- Revolving engine components such as radiator fans.
- Ground-driven components, only if operating personnel are required to be in the area while the drives are in motion.
- Moving traction elements (wheels or tracks) in relation to the operator's station.
- Hot surfaces such as radiators.
- Live electrical components such as battery posts.

1.3 Farm Machinery Guarding Procedure

This procedure was developed to provide farmers with simple guidelines to identify hazards, and design and fabricate guards to eliminate the hazards on their farm machinery.

1.3.1 Risk Assessment

Do not spark your cutting torches and welders right away. It is possible to fabricate and install a guard and still not ensure the machine is safe. In order to ensure your machinery is safe, it is important to take a moment and ask a few questions.

Risk Assessment is a series of steps that machinery designers use to examine the hazards associated with a machine. You are essentially starting this process when you decide to design and fabricate your own guards. For a detailed explanation of Risk Assessment see **Section 2.2** of this guide. The following steps summarize Risk Assessment.

PAMI Recommendation:
For each machine owned, photocopy the form in **Appendix VII** to record each step of the farm machinery guarding procedure. The time required to complete this procedure could be well worth it if it prevents just one injury.

What is the Function of the Machine?

The first simple questions you should answer are: What is the machine used for? What motions or actions does it perform? Also consider any misuse the machine might see in its lifetime.

What Hazards Exist?

Hazard identification includes all hazards, hazardous situations, and hazardous events associated with the machinery. Listed below are examples of hazards that may be present:

- Impact
- Crushing
- Stabbing and puncture
- Friction and abrasion
- Heat
- Electrical
- Compressed air or high-pressure fluid injection
- Entanglement
- Drawing-in
- Pinch points
- Thrown objects
- Cutting
- Shear

See **Section 2.3** of this guide for detailed explanations of these hazards. The following pictures show some common areas where these hazards exist. (**Figures 1, 2, 3, 4, and 5**)

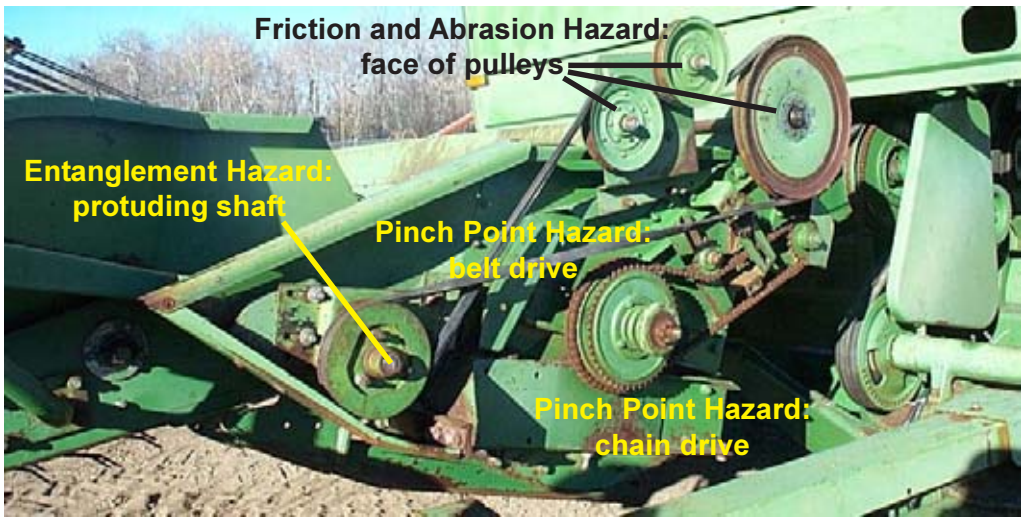

Figure 1. *The guards of drive belts, chains, and shafts of combine headers are often removed for service access and are not replaced.*

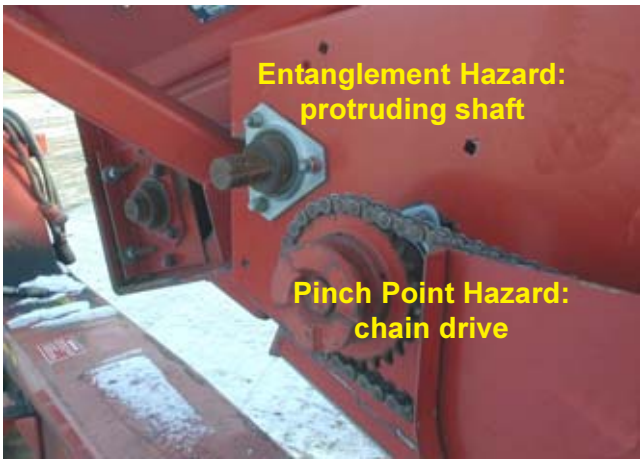

Figure 2. *Protruding shafts and chain drives are common hazards found on combine pickups.*

Figure 3. *Chains, belts, and shaft drives are common hazards found on augers.*

Figure 4. *Guards for PTO shafts are commonly removed and not replaced.*

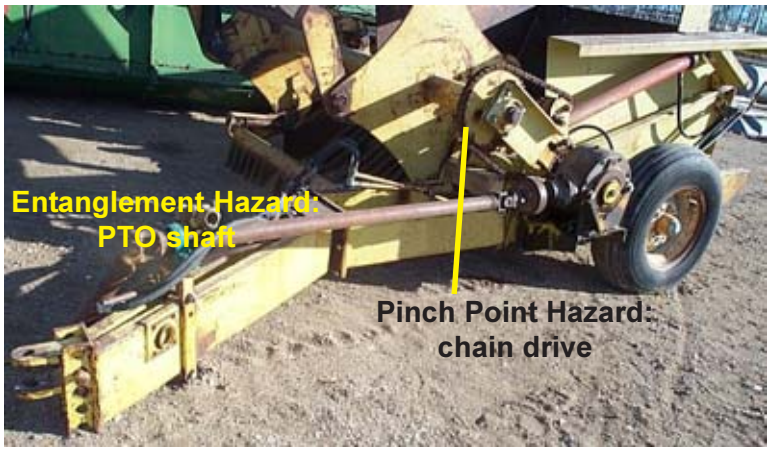

Figure 5. *PTO driven machinery like this rock picker have potentially fatal hazards if left unguarded.*

Risk Estimation

For each hazard identified, it is important to answer the following questions:

- What is the severity of possible injury?
- What is the probability of the injury occurring?

Total risk is the severity multiplied by the probability. The high-risk hazards should be safeguarded first. See **Section 2.2.3** of this guide for detailed explanations of these terms.

Risk Evaluation

Risk evaluation determines whether risk reduction is required or if safety has been achieved. If risk reduction is required then the following question should be asked:

- Will guarding reduce the risk?

Keep in mind not all hazards can be eliminated by guarding. Other forms of safeguarding not covered in this handbook may be required.

STATISTIC: *In Canada, there is an average of 10 fatalities per year caused by entanglement in agricultural machinery. This accounts for 10% of all agricultural machinery related fatalities.*[3]

PAMI Recommendation:
Before you start building a guard, there may be alternatives:

1. Purchase a new guard from a dealer... if there was an original one that was removed.
2. Purchase a used guard from a machinery wrecker...if there was an original that was removed.
3. Repair the existing guard...if it was removed due to damage.

1.3.2 Guard Type Selection

After risk assessment has been completed and it has been determined that guarding will reduce risk, guard selection can begin. Agriculture equipment dealers may be able to supply the proper guard. In many provinces, dealers are required to provide all replacement parts for a machine for 10 years after its production has ended. If your machine is older than this 10-year period, salvage yards may have the proper guard. If these sources are unsuccessful put on your safety glasses and continue on with this guide.

There are two types of guards:

- Fixed
- Movable

There are four classifications of guards:

- Local enclosing
- Fully enclosing
- Local distance
- Fully-surrounding distance guard

Section 2.4.2 provides further information on guard types and classifications. See **Appendix III** for a Guard Type Selection Flowchart.

3. Canadian Agricultural Injury Surveillance Program (CAISP). Agricultural Injuries in Canada for 1990 - 2000. 2003.

1.3.3 Guard Design, Fabrication, and Attachment

Guard Design

Proper guard design involves the following considerations. **Sections 2.4.3 and 2.4.4** give more detail on the considerations and design criteria for guards.

- Consider frequency of access required to the hazard.
- Is viewing of the guarded process or components required?
- Consider the size and weight.
- Ensure durability.
- The moving guard parts should be reliable.
- The guard should have sufficient impact resistance.
- Ensure no crushing or trapping points are created.
- Ensure there are no sharp edges created.
- The guard should be securely fixed to the machine.
- Warning decals should be applied.
- The guard should be resistant to corrosion.
- Appropriate guard colors should be used.
- Consider proper guard attachment methods.
- Safety Distances: Simply ensure that fingers or hands can't reach far enough through, around, along, or over the guard or barrier to access the hazard.

PAMI Recommendation:
Visit dealer lots, auctions, or other farmers to view similar machines to get ideas for guard design.

Guard Fabrication

PAMI Recommendation:
Be sure to use personal protection equipment like face shields and welding gloves during fabrication.

Material selection is the first fabrication step. Metal is the most common material used in guards for farm machinery. It is readily available, low cost, and durable. See **Section 2.4.5** for specific material recommendations.

- If a shield or enclosure is to be fabricated, using sheet steel with thin wall round tubing reinforcement is a common approach. This steel sheet could either be solid sheet metal, expanded mesh, or perforated sheet metal. Viewing of the hazard through the guard is easier if expanded mesh or perforated sheet metal is used.
- Where distance barriers are used, material such as round pipe and square tubing can be used.
- Use cardboard, duct tape, and a utility knife to acquire the basic dimensions for the guard. This could reduce wasted time and material in the end.

- After the basic dimensions are found, fabricate the external structural frame.
- Attach any required sheet metal, perforated metal, or expanded mesh walls next.
- After guard fabrication is complete be sure to paint the guard to prevent corrosion and affix safety decals to enhance hazard awareness. **Appendix V** includes a safety decal guide.

PAMI Recommendation:
Where hinged or removable guards expose dangerous parts (e.g. rotating shafts) paint the inside of the guards a bright distinguishing color. If it is not practical to apply the distinguishing color to the guard, then paint the dangerous items themselves. (Examples include: ends of shafts, rims of pulleys, edges of blades, sides of belts or chains, sides of sprockets, and sides of gears) This will give attention to any guard that has been removed and not replaced.

Guard Attachment

The guard attachment should be secure so it does not create any additional hazards. If a guard is difficult to detach then it will likely not be reattached. The most important consideration is the frequency of access to the hazard. If the hazard is accessed frequently for machine adjustment or service then a moveable guard should be used. If a hazard is seldom accessed (example: once per year of operation) then a fixed guard will provide the most durable and secure attachment. A fixed guard should still be easily removed with common hand tools. For further explanation and examples of the following attachment methods see **Section 2.4.4**:

- Bolted (fixed)
- Hinged / Latched (moveable)
- Hinged / Pinned (moveable)
- Dowels / Pinned (moveable)
- Sliding / Pinned (moveable)
- Slot and Tab / Pinned (moveable)

PAMI Recommendation:
Refer to **Appendix VI** for a guide on guard attachment components.

1.3.4 Is the Machine Safe?

After completing the process and affixing guards, this question should be asked to ensure there haven't been any additional hazards created. If it is determined that the machine still is not considered safe, then continue the process until safety is achieved.

PAMI Recommendation:
If you are having trouble finding a parts supplier for an uncommon brand of machinery, you may find these websites useful:
- www.cweda.ca (Canada West Equipment Dealers Association)
  - go to Links, then Obsolete/Hard to Find Parts
- www.orfeda.com (Ontario Retail Farm Equipment Dealers' Association)

2. Detailed User's Guide

2.1 Introduction

Guarding Standards

The majority of information for this handbook was gathered from the following standards organizations:

- CSA (Canadian Standards Association)
- ASAE (American Society of Agricultural Engineers)
- ISO (International Standards Organization)
- OSHA (U.S. Department of Labor / Occupational Safety and Health Administration)

See **Appendix I** for the specific standards and how to order them.

Prairie Agricultural Machinery Institute (PAMI)

PAMI is working in cooperation with Canadian Adaptation and Rural Development (CARD); Saskatchewan Agriculture, Food and Rural Revitalization, the Agriculture Development Fund (ADF); the Alberta AgTech Centre (ATC); and Bourgault Industries to deliver the **"On Guard!"** safety message to Canadian farm machinery owners and operators.

PAMI recommendations throughout this handbook note additional guarding suggestions, which may or may not be mentioned by standards organizations.

PAMI Recommendation:
Refer to **Appendix II** at the back of this book for a handy glossary of terms.

2.2 Risk Assessment

Risk assessment is done to determine the level of safety precautions necessary. All agricultural machine designers use this process to answer the question: Is the machine safe?

2.2.1 What are the limits of the machine?

The “limits of the machine” is simply its intended use. It is important to consider the purpose or function of the machine. This will help in the identification of hazards. Also consider any foreseeable misuse of the machine. The implementation of guarding should not inhibit the machines function.

2.2.2 Hazard Identification

What hazards are present? Just as important as the fabrication of the guard is the identification of the hazards to be guarded. Some hazards may appear obvious, but some may not be recognized as dangerous. See **Section 2.3** for examples of the hazards present in farm machinery.

2.2.3 Risk Estimation

Two factors of risk should be taken into account:

- **The Degree or Severity of Foreseeable Injury**

  Consider:

  - What type of mechanical or other hazard is involved?
  - What types of injuries can be foreseen?
  - What loss to the individual, the individual’s family, the employer, and the community does each possible degree of injury represent?

- **The Probability of the Injury Occurring?**

  Consider:

  - The frequency of access to or beyond a danger point during each phase of machine life (machine operation, breakdown, commissioning, maintenance, setting, and process changeover).
  - The proportion of each type of access likely to cause injury.
  - The absence of injury from machinery used without safeguards over a period of time does not mean that the machine is completely safe.

2.2.4 Risk Evaluation

Risk evaluation determines what safeguards are required for risk reduction. Even after all hazards have been guarded, it is important to consider any remaining risks associated with operating the machine. Many times it is not possible to guard against all potential hazards. The operator manual and safety decals should provide guidance on additional hazards.

STATISTIC: *Entanglement in a rotating PTO or drive shaft is the leading mechanism of entanglement fatalities accounting for 44% of all cases in Canada.*[4]

4. CAISP. 2003.

2.3 Types of Hazards

Entanglement

Entanglement occurs as a result of bodily contact with one of the following features:

- A single rotating surface
- Projections or gaps
- Counter rotating parts
- Rotating and tangentially moving parts
- Rotating and moving parts
- Rotating and fixed parts
- Material in motion

(**Figures 6, 7, 9, and 16**)

Figure 6. *This PTO auger has multiple hazards associated with it.*

Figure 7. *Protruding shafts with keyways are potential entanglement hazards.*

PAMI Recommendation:
Smooth shafts with no projections are not necessarily safe. Cut shafts and spindles off flush with bearings, sprockets, or pulleys wherever possible. If this is not possible, enclose the protruding shaft in a fixed-sleeve or cap-type guard constructed of suitable material, such as sheet metal. Plastic shaft-end caps are commonly used on new equipment and can be purchased at most agricultural dealerships.

Drawing-In

Drawing in occurs as the result of bodily contact with one of the following mechanisms:

- In-running nips between two counter-rotating parts
- In-running nips between a rotating surface and a tangentially moving surface.

(**Figures 8 and 13**)

Figure 8. *Loose clothing could be drawn in by these gears on a square baler.*

Pinch Points

Where two parts move together and at least one of them moves in a circle; also called mesh points, run-on points, and entry points (e.g. belt drives, chain drives, gear drives, and feed rolls). (**Figures 6, 9, and 16**)

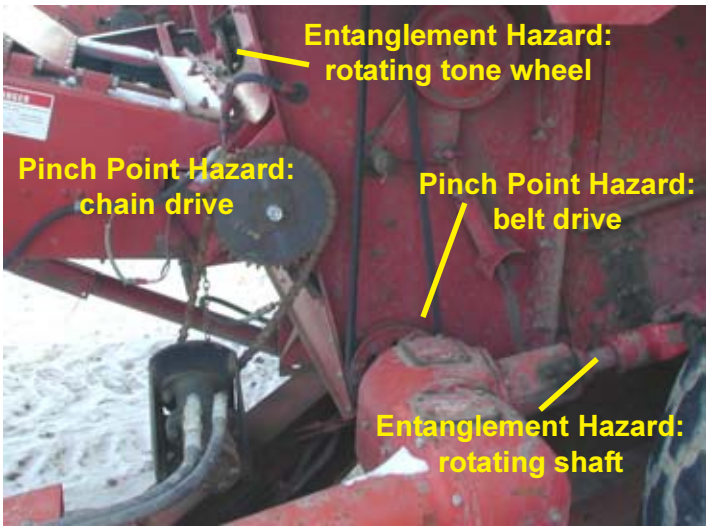

Figure 9. *Combines can be particularily dangerous because of multiple danger zones.*

Thrown Objects

Any object that can become airborne because of moving parts (e.g. rocks, stones, sticks, and pieces of chopped or cut crops). (**Figure 10**)

Figure 10. *Combine choppers and spreaders can be hazardous because of crop material or objects that become airborne.*

PAMI Recommendation:
To reduce the likelihood of stones and other objects being thrown at people, install a rubber or chain skirt around the openings and perimeter of rotary mowers and flails.

Cutting

Cutting occurs as a result of bodily contact with such items as cutting tools, blades, knives, or sharp parts. (**Figure 11**)

Figure 11. *The spinning spreader discs of combines should have a distance guard similar to the one in this picture.*

Shear

Parts of the body may be sheared between two machine parts or between a machine part and a work piece (e.g. rotary shredders and cutters, augers in tubes, chain and paddle conveyors). (**Figure 12**)

Figure 12. *Auger inlets are often left unguarded.*

Impact

Impact occurs as the result of bodily contact with objects acting against the body, but not penetrating it. (**Figure 13**)

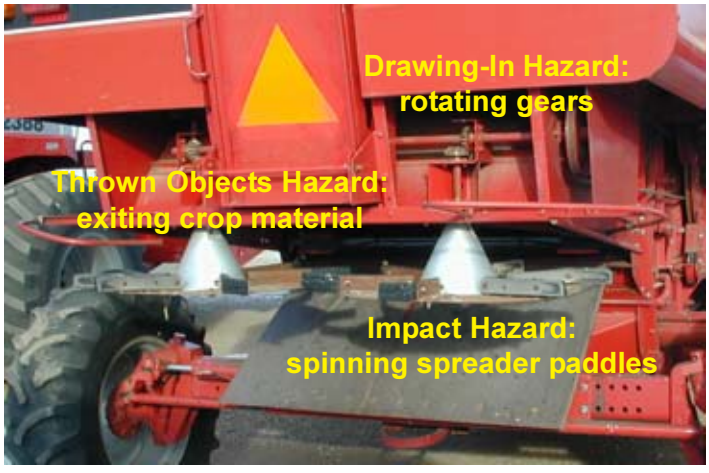

Figure 13. *The rear discharge area of combines have multiple danger zones.*

Crushing

Crushing occurs as the result of bodily contact between one part of machinery moving against another part. (**Figure 14**)

Figure 14. *The crushing hazard under raised headers can be eliminated by using hydraulic cylinder stops.*

Stabbing and Puncture

The body may be penetrated by flying objects or by rapidly moving parts. (**Figure 15**)

Figure 15. *Sharp edges like the ones on this square baler are a stabbing or puncture hazard.*

Friction and Abrasion

Friction and Abrasion occur as the result of bodily contact with relatively smooth parts operating at high speeds (e.g. The outside face of a pulley) or abrasive hazards (e.g. abrasive wheels or belt sanders). (**Figure 16**)

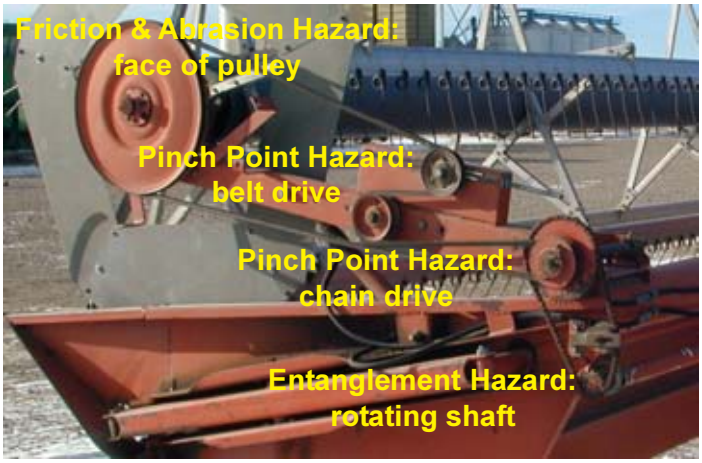

Figure 16. *The header drives of windrowers are often left unguarded.*

Compressed Air or High-pressure Fluid Injection

Compressed air or high-pressure fluid injection occurs as the result of skin exposure to high-pressure streams such as compressed air jets, high-pressure water, or steam, or hydraulic systems. (**Figure 17**)

Figure 17. *Pin hole hydraulic leaks are a hazard to the skin and eyes.*

PAMI Recommendation:
Whenever practical, hydraulic components and hoses should be positioned away from the operator zone or areas where people may be at risk. Consider re-routing hydraulic hoses away from the operator station. As an alternative, place the components and hoses behind guards. Use cardboard to source pinhole leaks in hydraulic systems, not your hand.

Heat

Any surface that reaches a temperature of 130°C (266°F) is considered a hot surface and should be guarded. (**Figure 18**)

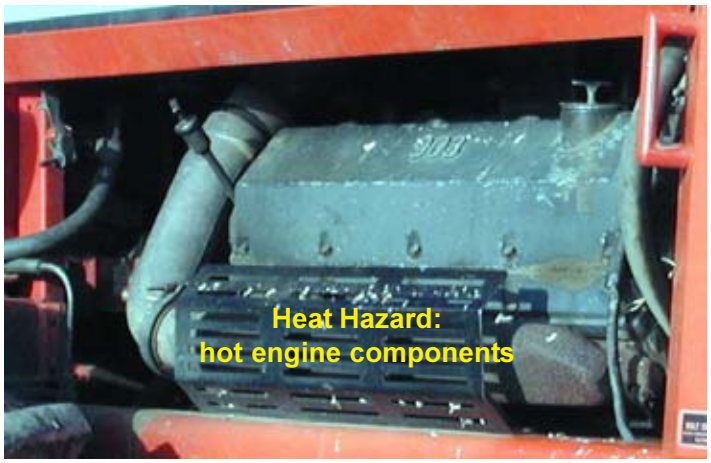

Figure 18. *Hot engine components that often need proper ventillation can be made safe with distance guards.*

PAMI Recommendation:
Skin burns will occur at surface temperatures below 130°C (266°F). Guard hot components when inadvertent contact is possible.

Electrical

Bare wires and unguarded battery posts pose potential spark hazards. Locate batteries away from operators or bystanders. (**Figure 19**)

Figure 19. *This electrical hazard could easily be eliminated by battery post covers or a battery box.*

2.4 Guard Design, Fabrication, and Attachment

2.4.1 Guard Principles

The principles below apply to guard design and construction for new farm machinery. These principles can also be used to provide guidance in the design and fabrication of guards for used machinery.

- Guards should not interfere with the normal operation of the machine.
- Guards should normally be permanently attached, which includes the use of threaded fasteners, split pins, hinges, or other methods that can be dismantled with common hand tools.
- Guards and access doors which must be opened for routine or daily service, inspection or cleaning should:
  - Be easy to open and close.
  - Remain attached when open; for example, by means of a hinge, slide, linkage, tether or other suitable methods.
  - Include a convenient and effective way to keep them closed.
- Guards should remain functional under the forces that could be applied by a 123 kg (270 lb) person leaning, stepping, or falling against them in normal operation or servicing of equipment.

- Guards should be designed and constructed with the object of preventing any part of the body from reaching a dangerous point or area.
- The design of guarding should ensure that the guards do not present a hazard such as trapping, shear points, rough or sharp edges, or other hazards likely to cause injury.
- Guard mountings should be compatible with the strength and duty of the guard.
- Guarding, where required, should minimize inadvertent contact with machinery hazards during normal mounting, starting, operating, dismounting, and servicing of the equipment. Operating instructions should be provided stating that guards must be kept in place, and/or that the machine should not be operated with guards removed.
- Guards should be weather resistant, and retain required strength under expected climatic and operational conditions for their intended use.
- Guards should not cause undue obstruction to the view of a process.
- Guards should be installed so that they do not cause interference with the activities of workers during operation, maintenance, etc. A proper installation should reduce any incentive to operate the machine without guarding.
- Guards should be permanently affixed to the machine, or, when this is not possible, to the same surface to which the machine is fixed. The removal of a fixed guard should require the use of tools. Fasteners should stay attached to the guard.
- Guards should protect an operator and others in the vicinity from materials, work pieces, chips, liquids, dust, fumes, gases, etc, that may be ejected, dropped, or emitted from a machine and that may present a hazard.
- Guards should allow for safe lubrication, inspection, and maintenance of the hazard area.

STATISTIC: *In Canada, there are an average of 228 hospitalized injuries per year where entanglement in agricultural machinery was the cause of injury. Entanglement is the leading mechanism of hospitalized injuries relating to agricultural machinery, accounting for 32 percent of all cases.*[5]

2.4.2 Guard Type and Classification

There are 2 main guard types associated with agricultural equipment:

- A **fixed guard** is a guard that is kept in place (i.e. closed) either permanently (by welding, etc.) or by means of fasteners (screws, nuts, etc.) making removal/opening impossible without the use of common hand tools.
- A **moveable guard** is a guard generally connected by mechanical means (e.g. hinges or slides) to the machine frame or an adjacent fixed element and which can be opened without the use of tools.

5. CAISP. 2003.

Each guard type may be classified as one of the following:

- A **local enclosing guard** alone or with other parts of the machine, provides protection from individual danger zones. (**Figure 20**)

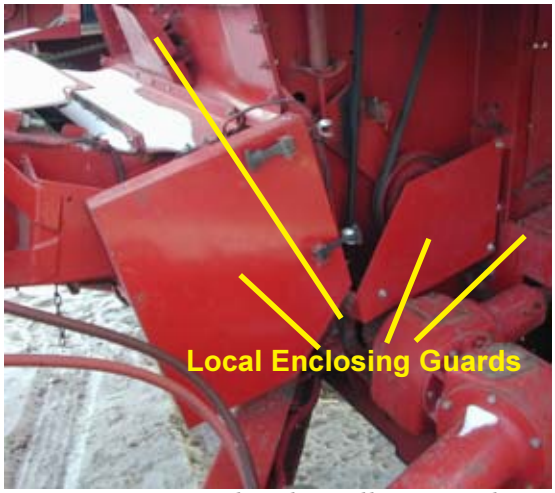

Figure 20. *Remember this pull-type combine from Figure 9?*

- A **local distance guard** is used when an enclosing guard is not practical to guard a low number of danger zones. It provides protection to individual danger zones by keeping people at a safe distance from the danger zone. (**Figure 21**)

Figure 21. *An enclosing guard would interfere with the function of this combine spreader disc.*

- A **fully enclosed guard** is used to guard multiple danger zones. It alone, or with other parts of the machine, provides protection on all sides. (**Figure 22**)

Figure 22. *One fully enclosing guard can often eliminate multiple danger zones like on this round baler.*

- A **fully surrounding distance guard** is a guard such as a rail, fence, or frame which is used when an enclosing guard is impractical and there are multiple danger zones. (**Figure 23**)

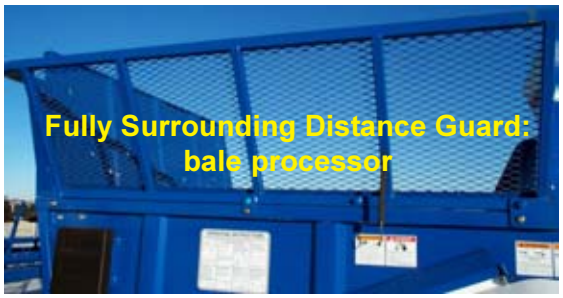

Figure 23. *This fully surrounding distance guard is designed to keep people at a safe distance from the danger zone. Notice the expanded mesh still provides viewing of the process.*

2.4.3 Guard Selection Criteria

Before fabrication of a guard, it is important to consider the following factors:

Frequency of Access to the Hazard

Consider the number of occasions on which access is required or foreseeable within the guarded area for a given period of time.

To minimize access to hazards where practical, guards and machinery shall be designed to enable routine adjustments, lubrication, and maintenance to be carried out without opening or removing the guards.

Where access is required within a guarded area, it shall be as free and unobstructed as practical. The following are examples of reasons for access:

- Loading and unloading material
- Tool changing and setting
- Measurement, gauging, and sampling
- Process observation
- Maintenance and repair
- Lubrication
- Removal of waste material
- Obstruction removal
- Machine cleaning

Where access is not required during use, fixed guards should be used because of their simplicity and reliability.

Viewing of Process or Components Being Guarded

Where viewing of machine operation is required through the guard, materials should be selected with suitable properties, e.g., if perforated material or wire mesh is used, this should be of adequate open area and suitable color to permit viewing. Viewing will be enhanced if the perforated material is darker than the area observed.

PAMI Recommendation:
Where possible, install extended lubrication lines so lubrication can be done without the removal of guards. Consider routing all lubrication lines to one lube bank in a safe location. Lubrication lines and banks are common on new agricultural machinery. Your local dealer can assist in the selection of these components.

Size and Weight

A guard should not be too large or heavy for one person to remove or open.

PAMI Recommendation:
If a guard is frequently removed or opened (once per day) it should take no longer than 30 seconds to be removed or attached by one person. This will increase the likelihood of the guard being re-installed.

Durability

The ASAE standard states that a guard must withstand a force of a123 kg (270 lb) individual leaning or falling against the guard. Be sure guards are durable enough to withstand any forces that they may see in their lifetime.

Reliability of Moving Guard Parts

If a guard is movable as a result of hinges, latches, slides, or handles, be sure that these components are durable enough to withstand any abuse over the entire life of the machine.

STATISTIC: *Tractors, augers, combines, and PTO shafts account for 50 percent of all agricultural machinery related hospitalized injuries in Canada.*[6]

Impact Resistance

The guard should withstand any foreseeable impact forces. Some examples of impact forces are: Persons falling against them, broken part ejection, or airborne material.

Crushing or Trapping Points Created

A guard should be safe to remove or open. Attention should be given to the attachment or latching points to ensure they will not pinch fingers or trap clothing.

Sharp Edges

Guards should be free of sharp edges, corners, or other hazardous projections which could catch clothing or cause cuts.

Secure Fixing

Guards should be securely fixed to the machine and able to withstand any vibration or forces during normal machine operation.

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6. CAISP. 2003.

Warning Signs

Where access within the guarded area can expose persons to residual risks, appropriate warning signs shall be placed near the latching or attachment points. Warning signs warn of the hazards being guarded and remind people not to operate the machinery without guarding in place. See **Appendix V** for standard warning decals and where to get them. (**Figures 24 and 25**)

Figure 24. *A safety decal warning of a thrown objects hazard.*

Figure 25. *A safety decal warning of a pinch point hazard from a belt drive.*

Resistance to Corrosion

Be sure to paint the guard to ensure it does not rust. Galvanized metal is a good guard material, as it will not rust.

Colors

Hazards can be highlighted by the use of suitable colors. For example, if a guard is painted the same color as the machine and the hazardous parts painted a contrasting bright color, attention is drawn to the hazard when the guard is open or left off.

Guard Latching Types and Attachment Methods

Where practical, guard fastenings shall remain attached to the guard as this reduces the likelihood of being lost and not replaced. See **Appendix VI** for a guard attachment component guide. Listed below are common guard attachment methods for agricultural machinery:

- Bolted (fixed) (**Figure 26**)
- Hinged / Latched (**Figure 27**)
- Hinged / Pinned (**Figure 28**)
- Dowels / Pinned (**Figure 29**)
- Sliding / Pinned (**Figure 30**)
- Slot and Tab / Pinned (**Figure 31**)

Figure 26. *Bolted Attachment*

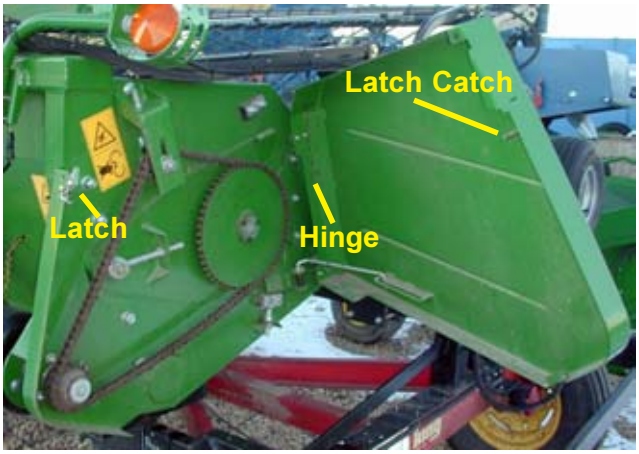


Figure 27. *Hinged / Latched Attachment*

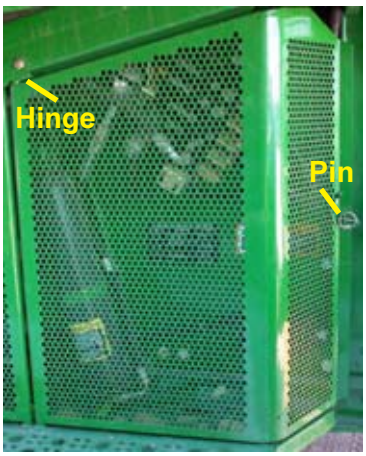


Figure 28. *Hinged / Pinned Attachment*

Figure 29. *Dowel / Pinned Attachment*

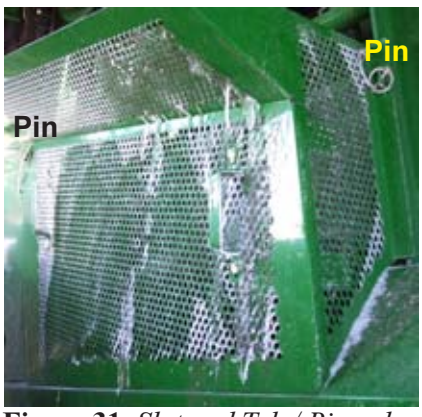


Figure 31. *Slot and Tab / Pinned Attachment*

Figure 30. *Sliding / Pinned Attachment*

2.4.4 Guard Material Suggestions

If a shield or enclosure is to be fabricated where there is at least one side to be completely guarded, it is recommended to use sheet steel. This steel sheet can either be solid sheet metal, expanded mesh, or perforated sheet metal. Viewing of the hazard through the guard is easier if expanded or perforated sheet metal is used. The suggested material can be purchased from any steel supplier, which can be found under "steel" in the yellow pages of your phone book. Also, search for steel suppliers on the PIMA - Agricultural Manufacturers of Canada website (www.pima.ca) under the member search area.

All prices listed below were estimated at the time this guide was written (2003).

Solid sheet metal provides the best protection from a hazard. It does not allow ejection of any material or failed parts. (**Figure 32**) It will not provide viewing of the hazard through the guard so it may be more often removed or opened. When ordering solid sheet metal from a steel supplier these are the specifications needed:

- Material - Mild steel
- Sheet thickness - 16 gauge (0.06 in)
- Dimensions – Width X Length required (stock size is 4 ft X 8 ft)
- Estimated price – $1.10 to $1.20 / sq ft

Figure 32. *Solid Sheet Metal Guard on the side of a combine.*

(Picture Courtesy of Bourgault Industries)

Expanded mesh allows viewing of the hazard, ventilation of the hazard, and drainage of fluids or material through the openings in the bottom of the guard. It also provides weight reduction for the guard. (**Figure 33**) When ordering perforated sheet metal from a steel supplier these are the specifications needed:

- Material – Mild steel
- Style – ½ in - 16 Standard diamond
- Dimensions – Width X Length required (stock size is 4 ft X 8 ft)
- Estimated price – $0.75 to $0.90 / sq ft

Figure 33. *An Expanded Mesh Guard like the one on this grain cart allows viewing of the hazard without removal of the guard.*

Perforated sheet metal possesses the same guarding characteristics as expanded metal, but is more expensive. This is the most common material used for guarding on new equipment because it is more esthetically appealing than expanded metal. When ordering perforated sheet metal from a steel supplier these are the specifications needed:

- Material – Mild steel
- Sheet thickness – 16 gauge
- Dimensions – Width X Length required (stock size is 4 ft X 8 ft)
- Perforation size – ¼ in diameter
- Perforation pattern – 3/8 in staggered centers
- Estimated price – $4.20 to $4.90 / sq ft

Figure 34. *This perforated sheet metal guard provides protection from all sides and allows viewing of the hazard without opening the guard.*

Round tubing works well in constructing the external framing for sheet metal guards. (**Figure 34**) When ordering round tubing from a steel supplier these are the specifications needed:

- Material – ERW Mild steel
- Wall thickness – 16 gauge
- Dimensions – ¾ in OD X Length required (stock length is 20 ft)
- Estimated price - $0.45 to $1.00 / ft

Not all guards will be enclosures. Where distance barriers are required, material such as Schedule 40 pipe or square tubing is recommended. When ordering pipe from a steel supplier, these are the specifications needed:

Schedule 40 Pipe:

- Material – Mild steel
- Dimensions – 1 in diameter X Length required (stock length is 21 ft)
- Estimated price – $0.85 to $1.00 / ft

Square Tubing:

- Material – ERW Mild steel
- Wall thickness – 16 gauge
- Dimensions – 1 in square X Length required (Stock length is 20 ft)
- Estimated price - $0.65 to $1.15 / ft

STATISTIC: *For every 21 hospitalized injuries related to entaglements in agricultural machinery there is 1 fatality in Canada.*[7]

7. CAISP. 2003.

2.4.5 Safety Distance Guarding

Safety distance guarding is minimizing the possibility of inadvertent contact with the hazard by the combination of the guard configuration (including openings) and the distance between the guard and the hazard. (**Figures 35, 36, and 37**)

- Consider safety distances when using expanded or perforated metal for the purpose of viewing a hazard through a guard. The distance that the surfaces of the guard should be away from the hazard depends on the size of the openings in the guard.
- It can be assumed that no reach is possible through an opening less than 10mm (3/8 in) square, as fingers do not fit in these size of openings. An opening 38 mm (1.5 in) square is the maximum safe opening permissible at a distance of 100 mm (4 in) from the hazard.
- The distance one can reach upwards from the ground or from any working platform is considered to be 2.5 m (8 ft - 2 in).
- Safety distance guarding should also be practiced when using barriers as guards. Perimeter fences serving as guards should be at least 1.8 m (5 ft – 11 in) high. The height of the barrier and location of the hazard determines how far away the barrier must be from the hazard. Ensure that by reaching up, over, around, or along, the barrier the hazard can't be accessed.

See **Appendix IV** for detailed information from ASAE on safety distance guarding.

Figure 35. *This expanded mesh barrier keeps people at a safe distance away from the rotating flails of a bale processor.*

Figure 36. *The distance guard on this feed processor keeps workers at a safe distance from the rotating knives when the cover is open.*

Figure 37. *The worker cannot reach into the danger zone.*

PAMI Recommendation:
The effectiveness of a guard with openings or a distance barrier should be judged by a reach test carried out with the machinery at rest in a safe condition. Keep in mind a person can reach upwards, over, around, along, and into to access a danger zone.

2.5 Is the Machine Safe?

After guarding the machine, it is important to step back and ensure that the machine is safe. Ensure there is no interference between the guards and the hazards. Inspect the guards after the machine's first use to be sure there is no rubbing, excess vibration, or material build-up around the guards.

3. Farm Machinery Guarding Example

3.1 Introduction

To show an actual example of the process, a portable grain auger was chosen because it is the third leading cause of machinery injuries on Canadian farms. Augers are associated with multiple hazards, not just the auger inlet. The precautions taken in this example, deal not only with guarding of hazards, but promote overall auger safety.

STATISTIC: *There are an average of 60 injuries per year in Canada where an auger was the cause of injury.*[8]

The Farm Machinery Guarding Procedure form in **Appendix VII** was used to guide the fabricator through the guarding procedure for the auger. Throughout the guarding of the auger, the time required, material used, and approximate cost were recorded.

3.2 Risk Assessment

What is the Function of the Machine?

The function of the auger is to convey grain from the auger inlet to the outlet at a higher position. Other things to keep in mind:

- A hand-powered winch can adjust the angle of incline of the auger.
- The auger is powered by an electric motor.
- From the electric motor, the auger is belt driven to a 90-degree gearbox, the power is then transmitted through a long drive shaft to the top of the auger, and lastly transmitted through a chain drive to the rotating auger screw.

What Hazards Exist?

How many hazards do you think are associated with an auger? We identified 8 hazards in 4 different areas on this particular auger! The auger inlet guard was already in place on this auger, are your auger inlets guarded? The chain drive at the top of the auger and the majority of the long drive shaft were also guarded.

8. CAISP. 2003.

- **Driver pulley** (**Figure 38**):
  1. **Pinch Point hazard** between the pulley and the belt
  2. **Entanglement hazard** from the protruding shaft
  3. **Friction hazard** with the exposed outside face of the pulley

Figure 38. *The driver pulley of an auger.*

- **Driven pulley** (**Figure 39**):
  4. **Pinch Point hazard** between the pulley and the belt.
  5. **Entanglement hazard** from the protruding shaft.
  6. **Friction hazard** with the exposed outside face of the pulley.

Figure 39. *The driven pulley of an auger.*

- **Drive shaft** (**Figure 40**):
  7. **Entanglement hazard** from the drive shaft and exposed bolt where the existing shield is broken.

Figure 40. *The exposed drive shaft.*

- **Over head power lines**:
  8. **Electrical hazard** from the top of the auger contacting over-head power lines making electrocution possible when moving the auger.

STATISTIC: *The majority of auger related injuries were due to entaglement at 77.7 percent, but a surprising 11 percent resulted from being pinned or struck by an auger or part of an auger.*[9]

Risk Estimation

- ***What is the severity of the possible injury and what is the probability of it occurring?***

  By our ratings the driver pulley was rated as the hazard with the highest risk. It was addressed first. The driven pulley was rated with the second highest risk so it was guarded next.

9. CAISP. 2003.

Risk Evaluation

For each hazard identified, the following questions were asked:

- ***Is risk reduction required?***
  For every hazard the answer was yes.

- ***Can guarding reduce risk?***
  For all hazards the answer was yes except for the over-head power line hazard. It is difficult to guard against the auger contacting a power line. Workers must be aware of over-head power lines when moving augers. A warning decal is in place as a reminder. (**Figure 41**)

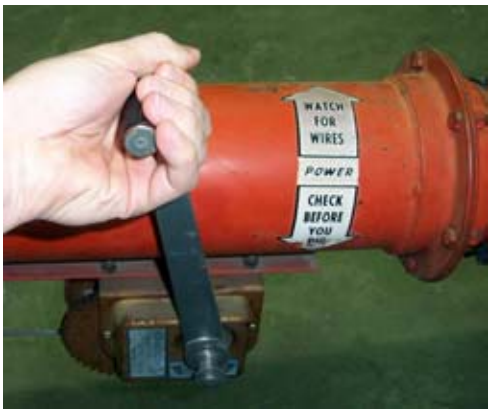


Figure 41. *The over-head wire safety decals were located near the hand winch and near the auger inlet.*

3.3 Guard Selection

The following questions were asked of each hazard:

- ***Can the guard be purchased from a dealer or wrecker?***

  The auger was old enough that existing guards were difficult to source. The existing guards were most likely removed and not re-installed because they were a hassle to remove. For the purpose of this example all guards were fabricated.

- ***Could the hazard be accessed more than once per year?***

  For the drive shaft hazard, the answer was no. In this case, a fixed guard was attached.

  The pinch point, entanglement, and friction hazard at the driver pulley may be accessed often for changing the belt or crossing over the belt to reverse the auger for clean out. The same situation occurs at the pinch point, entanglement, and friction hazards at the driven pulley. For these reasons moveable guards were decided upon.

- ***What guard classification to use?***

  The flow chart in Appendix III was used to determine the guard classification to use for the driver pulley hazard:

  - The driver pulley hazard is in a defined zone.
  - All access can be prevented.
  - The number of danger zones is high. There is the pinch point between the rotating pulley and belt, the protruding rotating shaft creates an entanglement hazard, and the exposed pulley face creates a friction hazard.
  - Therefore a (moveable) fully enclosed guard should be used.

  A similar process was used to choose a guard classification for all other hazards.

STATISTIC: *August to November are the most common months for auger related injuries to occur at 45 percent of 602 total cases in Canada from 1990 to 2000. There is also a slight rise in May at 11 percent of all cases.*[10]

10. CAISP. 2003.

3.4 Guard Design, Fabrication, and Attachment

Guard Design

The design details of the driver pulley guard follow.

- ***Is Viewing of the hazard required through the guard?***

  It was decided to allow viewing of the driver pulley so workers will not be inclined to remove the guard when ensuring the belt drive is operating properly. The side facing the worker will be made from expanded mesh material.

- ***Is the guard material resistant to the working environment?***

  Since the driver pulley guard will be made out of metal and the auger is exposed to the outside environment, the guard was painted.

A similar process was used to design guards for all other hazards.

Guard Fabrication

The fabrication process of the driver pulley guard follows.

- The fabrication started with the external frame. The material used was ¾ inch square tubing (0.062 in wall).
- The external walls were then constructed of 16-gauge sheet metal except the door, which was constructed of ½ in – 16 standard diamond expanded mesh. The door was reinforced with 1 in X 1/8 in flat bar around the edges. (**Figures 42 and 43**)

Figure 42. *The sheet metal walls.*

Figure 43. *The expanded mesh door before installation.*

- A 3 inch hinge purchased from a hardware store was welded to both the door and frame.
- Locating the hinge on top allowed the door to be swung up to stay out of the way for service, but then easily swung back for repositioning.
- A latch, also purchased from a hardware store, was welded to the door and the latch catch welded to the frame. (**Figure 44**)

Figure 44. *The hinge and latch are installed.*

- The outsides of the guards were painted black and the hazards painted a bright yellow to draw attention to the hazard. The inside of the guards were also painted a bright yellow to draw attention to them when they are open or removed. (**Figures 45 and 46**)

Figure 45. *Driven pulley completely guarded.*

Figure 46. *The inside of the guard and hazardous components were painted.*

- A safety decal was added after painting. (**Figure 47**)

Figure 47. *Safety decal installed.*

- The tools required for fabrication were a grinder, a zip cut wheel for the grinder, welder, drill, and a hole saw bit for the drill to cut out a slot for the drive shaft to pass through the guard.

Guard Attachment

The external frame of the driver pulley guard was bolted to the motor mount frame with ¼ in bolts and nuts. (**Figure 48**)

Figure 48. *The guard frame bolted to the motor mount frame.*

STATISTIC: *Augers accounted for 8.6 percent of all machinery related injuries in Canada.*[11]

3.5 Is the Machine Safe?

- A reach test was performed to test the effectiveness of each guard. (**Figure 49**) It was found that the guards were effective yet still practical.
- The auger was operated for a short time and then the guards inspected to ensure proper function.

Figure 49. *Conducting a reach test.*

11. CAISP. 2003.

Figure 50. *The driven pulley guard.*

Figure 51. *The driven pulley guard with the hinged door open.*

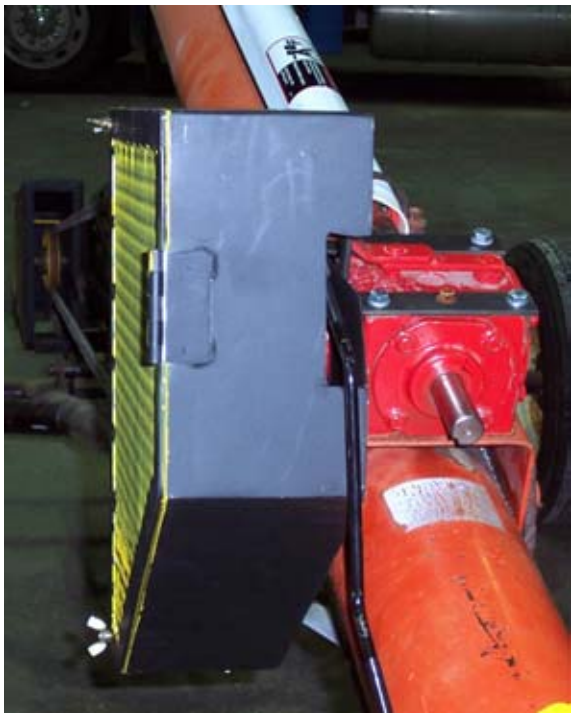


Figure 52. *The attachment of the driven pulley guard.*

Figure 53. *The plastic drive shaft guard.*

See Table 1 on pages 32 and 33 for a copy of the completed Farm Machinery Guarding Procedure Form for the auger.

Table 1. *Example of completed Farm Machinery Guarding Procedure*

Farm Machinery Guarding Procedure					
Date: Feb 17-20/04		**Location:** Humboldt, SK			
Machine: 6" Electric Auger		**Persons performing procedure:** Joe Farmer			
1. Risk Assessment (See Section 2.2)					
1.1 What is the Function of the Machine? (See Section 2.2.1)					
Transfer grain from the inlet to the outlet.					
1.2 What Hazards Exist? (Check off) (See Section 2.3)					
Hazard Type	**Hazard Number and Description**				
	1: Driver pulley	2: Driven pulley	3: Drive shaft	4: Over-head power lines	5:
A) Entanglement?	✓	✓	✓		
B) Drawing-In?					
C) Pinch Points?	✓	✓			
D) Thrown Objects?					
E) Cutting?					
F) Shear?					
F) Impact?					
G) Crushing?					
H) Stabbing and Puncture?					
I) Friction?	✓	✓			
J) High-pressure injection?					
K) Heat?					
L) Electrical?				✓	
M) Other?:					
1.3 Risk Estimation (See Section 2.2.3)					
A) What is the severity of possible injury? (Choices: Minor=1, Severe=5, Fatal=10)	7	7	7	10	
B) What is the probability of the injury occurring? (Choices: Low=1, Medium=5, High=10)	5	3	1	2	
C) Calculate Total Risk Rating? (Safeguard highest ratings first) (Total Risk= Severity X Probability)	35	21	7	20	
1.4 Risk Evaluation (See Section 2.2.4)					
A) Is risk reduction required? (Yes=continue, No=go to step 4)	(Yes) / No	(Yes) / No	(Yes) / No	(Yes) / No	Yes / No
B) Can guarding reduce risk? (Yes=continue No=other means of safeguarding required)	(Yes) / No	(Yes) / No	(Yes) / No	Yes (No)	Yes / No

2. Guard Type Selection (See Section 2.4.2)					
A) Can the guard be purchased from a dealer or wrecker? (No=continue, Yes=go to step 4)	Yes (No)	Yes (No)	Yes (No)	Yes / No	Yes / No
B) Could the hazard be accessed more than once per year? (Yes=use movable guard type, No=use fixed guard type)	(Yes) / No	(Yes) / No	Yes (No)	Yes / No	Yes / No
A) What guard classification to use? Refer to Appendix III for a selection flow chart of: Local Enclosing, Fully Enclosing, Local Distance, Fully Surrounding Distance Guard	Fully Enclosing	Fully Enclosing	Local Enclosing	_____	_____
3. Guard Design, Fabrication, and Attachment (See Section 2.4)					
3.1 Guard Design					
A) Is viewing of the hazard required through the guard? (Yes=perforated or expanded metal, No=sheet metal, see Section 2.4.5)	(Yes) / No	(Yes) / No	Yes (No)	Yes / No	Yes / No
B) Is the guard material resistant to the working environment? (Yes=Continue, No=paint or apply protective coating)	Yes (No)	Yes (No)	(Yes) / No	Yes / No	Yes / No
3.2 Guard Fabrication					
A) Is the guard durable and reliable? (Yes=continue, No=redesign to strengthen components)	(Yes) / No	(Yes) / No	(Yes) / No	Yes / No	Yes / No
B) Are warning signs applied? (Yes=continue, No=apply warning signs, see Appendix V)	(Yes) / No	(Yes) / No	(Yes) / No	(Yes) / No	Yes / No
C) Does the guard create any additional hazards? (No=continue, Yes=redesign to reduce risk)	Yes (No)	Yes (No)	Yes (No)	Yes / No	Yes / No
D) Can the hazard be accessed through or around the guard? (No=continue, Yes=redesign to prevent access)	Yes (No)	Yes (No)	Yes (No)	Yes / No	Yes / No
3.3 Guard Attachment to the Machine					
A) What attachment method is most practical in this case? Refer to Section 2.4.4 and Appendix VI for Attachment Methods: Bolted (fixed), Hinged/Latched, Hinged/Pinned, Dowels/Pinned, Sliding/Pinned, Slot+Tab/Pinned	Hinged/Latched	Hinged/Latched	Bolted	_____	_____
B) Is the guard securely fastened? (Yes= continue, No=strengthen attachment method)	(Yes) / No	(Yes) / No	(Yes) / No	Yes / No	Yes / No
C) Can the guard be easily removed or opened by one person? (Yes=continue, No=redesign to reduce weight or size)	(Yes) / No	(Yes) / No	(Yes) / No	Yes / No	Yes / No
4. Is the Machine Safe? (YES) / NO (No=return to step 1.2, Yes=process complete!)					

NOTE: The following information is to be used to help farm machinery owners and operators retrofit their used machinery with proper guarding. It does not replace or supersede any ASAE, CSA, OSHA, or ISO standards and is not a legal document used for law enforcement.

3.6 Materials, Time, and Money Used

A record of the materials, time, and money required was kept throughout the guarding of the auger. For the 3 guards to be fabricated it took 11.5 hours for one person and only $41.68 worth of material. So as long as you can find the time, fabricating your own guards should be inexpensive. See **Table 2** for the detailed auger guarding record.

Table 2. *Auger Guarding Record*

Hazard Number	Description	Material Used	Unit Price	Money Spent	Time Required (hrs)
1	Driver pulley	116.5 in of 3/4 in square tubing (0.062 in wall)	$0.49 / ft	$4.76	6
		2.5 in of 1.5 in X 1/4 in flat bar	$1.95 / ft	$0.41	
		242 sq in of 16 gauge sheet metal	$1.09 / sq ft	$1.83	
		46.5 in of 1 in X 1/8 in flat bar	$0.25 / ft	$0.97	
		132 sq in of 1/2 in - 16 standard diamond expanded mesh	$0.78 / sq ft	$0.72	
		2 of 1/4 in X 3/4 in bolts with nuts	$0.25 each	$0.50	
		3 in Stanley plated hinge from Peavey Mart	$1.00 each	$1.00	
		Latch from Peavey Mart	$2.00 each	$2.00	
		Safety Decal	$6.50 each	$6.50	
2	Driven pulley	126 in of 1 in X 3/16 in flat bar	$0.35 / ft	$3.68	5
		528.5 sq in of 16 gauge sheet metal	$1.09 / sq ft	$4.00	
		270 sq in of 1/2 in - 16 standard diamod expanded mesh	$0.78 / sq ft	$1.46	
		3 in Stanley plated hinge from Peavey Mart	$1.00 each	$1.00	
		2 of 3/8 in X 2 3/8 in wing bolts with nuts	$0.50 each	$1.00	
		Safety Decal	$6.50 each	$6.50	
3	Drive shaft	6 in of 3 in ID X 1/4 in wall round plastic tubing	$2.00 / ft	$1.00	0.5
		Safety Decal	$4.35 each	$4.35	
Total				**$41.68**	**11.5**

4. Questions and Answers

When is a guard required?

A guard is required when there is the possibility of harm to the operator or bystanders from a hazard.

When is a guard not required?

A guard is not required when a hazard is guarded by location. Guarded by location means that the hazard can not be physically accessed because of the design of the machine components and location of the hazard. For example, the drive shaft under a vehicle. Guards are not required for smooth shafts rotating at less than 10 rpm and smooth shaft ends protruding less than half the outside diameter of the shaft. Guarding is also not required if it interferes with machine function. (**Figure 54 and 55**)

Figure 54. *A guard is not required at the discharge of this feed mixer as it would interfere with the function of the machine.*

Figure 55. *A guard is not required at the inlet of this forage harvester as it would interfere with the feeding of material.*

What should I consider guarding first?

The first hazard guarded should be one which poses the greatest severity of injury and carries the most likelihood of the injury occurring. **Section 2.2** contains more information on risk assessment.

Do ground-driven components need to be guarded?

Ground-driven components need to be guarded only if operating personnel are required to be in the area while the drives are in motion.

What types of hazards should I look to guard?

Any mechanical hazard such as rotating shafts, nip points, gears, pinching hazards, shearing hazards, pulleys, sheaves, and sprockets. Hot surfaces and electrical hazards should also be guarded. **Section 2.3** contains more information on types of hazards.

What material should I use when fabricating a guard?

Most guards are made of metal as they provide the best durability and protection from the environment. Solid sheet metal, expanded mesh, or perforated metal are common materials used. Thin walled round tubing provides good structural support. **Section 2.4.5** contains a list of recommended materials.

How should I attach the guard?

The guard should be securely attached so that inadvertent contact does not damage or dislodge the guard. Frequency of access to the hazard is important in deciding how to attach the guard. If minimal access is required, attach the guard using bolts or screws. If frequent access is required, consider hinging the guard and using a latch that can be operated by hand. See **Appendix VI** for a list of suggested guard attachment components.

PAMI Recommendation:
If access to the hazard is required only once per year for maintenance use a fixed guard that is attached by fasteners, which require tools. If the hazard being guarded requires access more than once per year for maintenance or adjustment use a moveable guard that is easily removed or opened and reinstalled. Use fasteners and latches that stay attached to the guard or machine so they are not lost when removed. These considerations will increase the likelihood of the guard being reinstalled after removal.

Where can I purchase safety-warning decals?

Safety warning decals can be purchased from any major agricultural equipment dealer or safety supply companies. See **Appendix V** for a list of useful safety decals.

Appendix I
Related Standards

Safety of Machinery – Guards – General Requirements for the Design and Construction of Fixed and Moveable Guards, ISO Standard 14120, First Edition 2002-02-01

Guarding for Agricultural Equipment, ANSI/ASAE Standard S493.1 JUL03

Safeguarding of Machinery – Occupational Health and Safety, CSA Standard Z432-94, July 1994

Guarding of Farm Equipment, Farmstead Equipment, and Cotton Gins, U.S. Department of Labour, Occupational Safety and Health Administration Standard 1928.57

Standards can be ordered from:

American Society of Agricultural Engineers (ASAE)
2950 Niles Rd, St. Joseph, MI 49085-9659
Phone: 616-429-0300 Fax: 616-429-3852
Email: hq@asae.org
Website: http://www.asae.org

Canadian Standards Association (CSA)
5060 Spectrum Way, Mississauga, ON L4W 5N6
Phone: 1-800-463-6727 (Canada and US) or 416-747-4044
Fax: 416-747-2510
Email: sales@csa.ca
Website: http://www.csa.ca

International Organization for Standardization (ISO)
1, Varembe Street, Postal Box 56
CH-1211 Geneva 20, Switzerland
Phone: +41 22 749 01 11 Fax: +41 22 733 34 30
Website: http://www.iso.ch/iso/en/ISOOnline.frontpage
NOTE: In Canada, puchase standards at IHS Canada website and e-mail
Email: gic@ihscanada.ca
Website: http://www.ihscanada.ca

U.S. Department of Labour / Occupational Safety and Health Administration (OSHA)
OSHA Publications
P.O. Box 37535 Washington, D.C. 20013-7535
Telephone: (202) 693-1888
Fax: (202) 693-2498
Website: http://www.osha.gov

Appendix II
Glossary of Terms

ASAE: American Society of Agricultural Engineers

CSA: Canadian Standards Association

CAISP: Canadian Agricultural Injury Surveillance Program

Danger: A state of condition in which personal injury is reasonably foreseeable.

Danger zone: The zone around the machine (front, back, sides, top, and bottom) where a hazard is created by the motion of the machine components.

Distance guard: A guard that does not completely enclose a danger zone, but which prevents or reduces access by virtue of its dimensions and its distance from the danger zone.

Enclosing guard: A guard that prevents access to the danger zone from all sides.

Fixed guard: A guard kept in place either permanently or by means of fasteners, making removal / opening impossible without using tools.

Ground-driven components: Components, which are powered by the forward or rearward motion of equipment traveling over the ground.

Guard: A physical barrier that prevents access to a danger zone.

Guarded by location: A hazard is guarded by location when it is guarded by other parts or components of the machine that are not themselves guards, or when the hazard is beyond the safety distance.

Hazard: A situation that may cause injury to a person.

Hot surface: A surface which reaches operating temperatures in excess of 130 °C (266 °F) and which could involve injury by inadvertent contact.

Inadvertent contact: Unplanned contact between a person and a hazard, resulting from the person's actions during normal operation or servicing of equipment.

ISO: International Standards Organization

Machinery: Apparatus for producing or applying power, having fixed or moving parts each with definite functions. This includes powered and non-powered machinery such as pulled implements. The term machinery also includes stationary equipment such as seed processing machinery and livestock handling equipment.

Machinery hazard: Machinery parts, which can cause injury upon direct contact or by entanglement of personal apparel. This includes, but is not limited to, pinch points, nip points, and projections on rotating parts.

Moveable guard: A guard generally connected by mechanical means to the machine frame or an adjacent fixed element and which can be opened without the use of tools.

Nip-point: A type of pinch point characteristic of components such as meshing gears and the run-on point where a belt, chain, or cable contacts a sheave, sprocket or idler.

Operator: Any person responsible for the operation of the equipment.

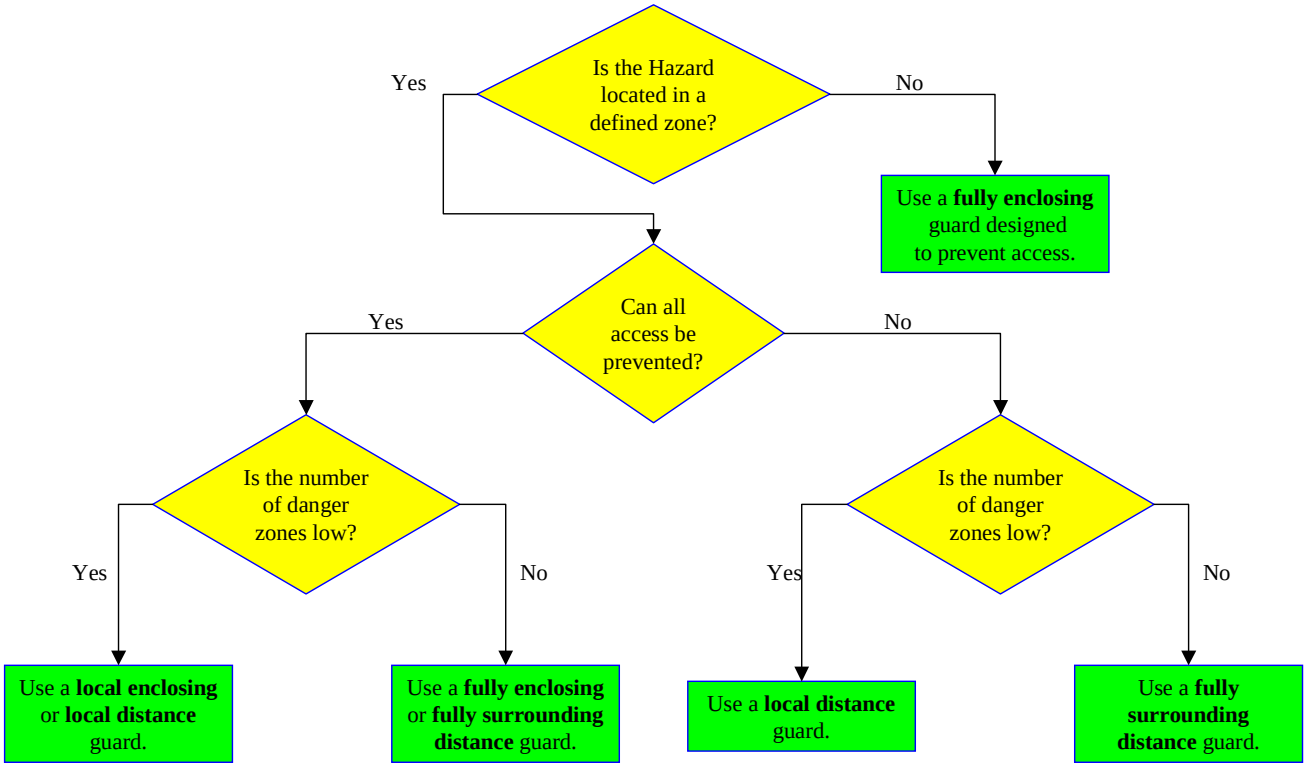
OSHA: Occupational Safety and Health Administration, United States Department of Labour

Risk: A combination of the probability of injury and the degree of injury.

Safeguard: A guard or device designed to protect persons from danger.

Safety distance guarding: A method of providing guarding where the possibility of inadvertent contact with the hazard is minimized by the combination of the guard configuration (including openings) and the distance between the guard and the hazard. An additional aspect includes separation dimensions of pinch points in relation to body parts.

Appendix III
Guard Classification Flow Chart



Appendix IV
Safety Distance Guarding

Reach Over Barriers

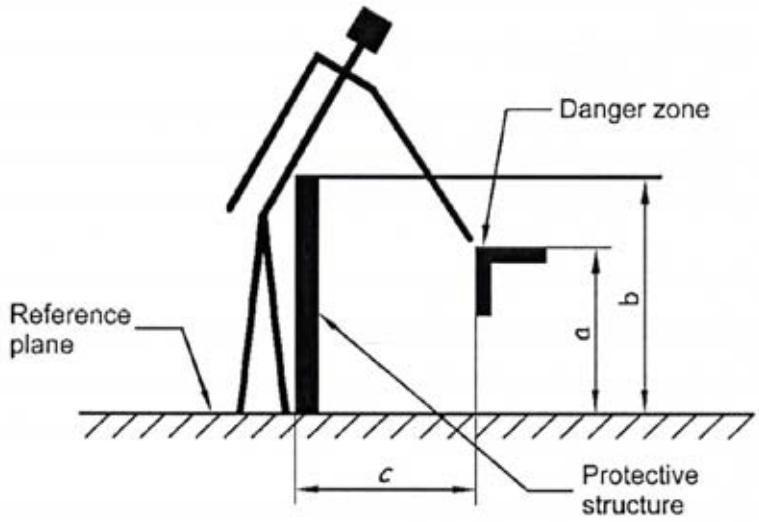


Figure 3

Table 1
Reach Over Barriers Dimensions in Millimeters

Height of danger zone, *a*	Height of protective structure, *b*[1)]								
	1 000	1 200	1 400	1 600	1 800	2 000	2 200	2 400	2 500
	Horizontal distance to danger zone, *c*								
2 500 [2)]	–	–	–	–	–	–	–	–	–
2 400	100	100	100	100	100	100	100	100	–
2 200	600	600	500	500	400	350	250	–	–
2 000	1 100	900	700	600	500	350	–	–	–
1 800	1 100	1000	900	900	600	–	–	–	–
1 600	1 300	1000	900	900	500	–	–	–	–
1 400	1 300	1000	900	800	100	–	–	–	–
1 200	1 400	1000	900	500	–	–	–	–	–
1 000	1 400	1000	900	300	–	–	–	–	–
800	1 300	900	600	–	–	–	–	–	–
600	1 200	500	–	–	–	–	–	–	–
400	1 200	300	–	–	–	–	–	–	–
200	1 100	200	–	–	–	–	–	–	–
0	1 100	200	–	–	–	–	–	–	–

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Table 2
Extent of Reach Around Barrier

Dimensions in millimeters

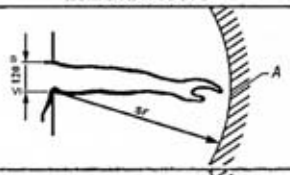
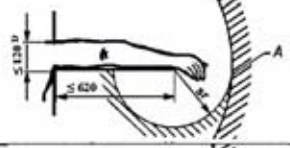
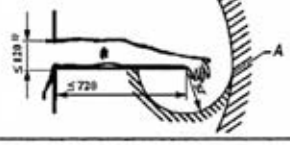
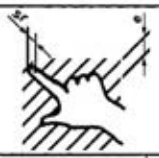
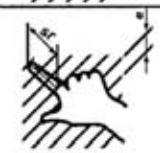
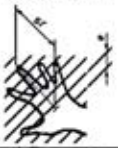
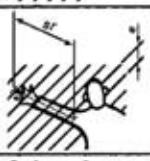
Limitation of Movement	Safety Distance, sr	Illistration
Limitation of movement only at shoulder and armpit	≥ 850	
Arm supported up to elbow	≥ 550	
Arm supported up to wrist	≥ 230	
Arm and hand supported up to knuckle joint	≥ 130	
A is the range of movement of the arm 1) This is either the diameter of a round opening, or the side of a square opening, or the width of a slot opening.		

Table 3
Inside Reach Through Guards

Dimensions in millimeters

Part of Body	Illustration	Opening	Safety distance, sr		
			Slot	Square	Round
Finger tip		e ≤ 4	≥ 2	≥ 2	≥ 2
		4 < e < 6	> 10	> 5	> 5
Finger up to knuckle joint Or hand	 	6 < e ≤ 8	≥ 20	≥ 15	≥ 5
		8 < e ≤ 10	≥ 80	≥ 25	≥ 20
		10 < e ≤ 12	≥ 100	≥ 80	≥ 80
		12 < e ≤ 20	≥ 120	≥ 120	≥ 120
		20 < e ≤ 30	≥ 850	≥ 120	≥ 120
Arm up to junction with shoulder		30 < e ≤ 40	≥ 850	≥ 200	≥ 120
		40 < e ≤ 120	≥ 850	≥ 850	≥ 850
1) If the length of the slot opening is ≤ 65 mm, the thumb will act as a stop and the safety distance can be reduced to 200 mm.					

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Appendix V
Safety Decal Guide

Make	Part Number	Price (Can$)	Description
John Deere	E82510	$6.50	Caution, keep guards in place
	E82514	$4.35	Danger, entanglement in rotating driveline can cause serious injury or death
	H209453	$8.50	Danger, do not open cleanout doors with engine running
	H149096	$8.50	Warning, stay clear of flying objects while engine is running
	H149099	$6.50	Warning, never raise shield while engine is running
	H149067	$9.75	Warning, high pressure fluid injection
	H169344	$7.00	Warning, hot liquid under pressure
	H149062	$8.00	Danger, do not enter grain tank while engine is running
	H151397	$4.75	Caution, avoid contact with rotating auger
Case IH	181595A1	$9.22	Warning, do not open until all mechanisms have stopped
	144388A1	$9.21	Warning, stay clear of flying objects while engine is running
	144383A1	$9.22	Danger, do not enter grain tank while engine is running
	144386A1	$9.55	Danger, keep hand out of auger sump while engine is running
	144385A1	$5.06	Warning, shields are provided to guard these moving parts
	181475A1	$9.22	Warning, contact with belt may engage drive, stop engine
	181597A1	$9.22	Warning, do not enter drive area while engine is running
	191129A1	$5.06	Warning, avoid injury. Shut off engine before adjusting or servicing
AGCO	71379128	$4.39	Warning, keep shields in place
	71379126	$3.87	Warning, escaping fluid under pressure can penetrate skin
	111670W1	$1.03	Warning, do not open until engine and all movement have stopped
	111091W1	$1.38	Danger, shield missing do not operate
	71379127	$2.54	Warning, stay clear of flying objects while engine is running
	111737W1	$1.73	Warning, stop engine and wait for all movement to stop before servicing chopper
	111743W1	$0.72	Warning, keep hands away from cleanout opening when engine is running
	111736W1	$2.87	Danger, stop engine and remove key before entering grain tank
	713112163	$16.63	Warning, keep out of engine compartment while engine is running
	3609336M1	$5.82	Warning, high pressure steam and hot water
New Holland	267065	$2.83	Warning, rotating augers. Do not enter grain tank when machine is operating
	684145	$4.88	Warning, stand clear, rotating flails under hood: crop material exiting at high speed
	703810	$3.23	Warning, rotating parts under this cover
	703810	$3.23	Warning, rotating parts under this cover may continue to rotate
	684145	$4.88	Warning, Stand clear, Rotating flails under hood
Note: Prices were at the time this guide was written (2003), see your local dealer for more information.			

Appendix VI
Guard Attachment Component Guide

Make	Part Number	Quantity	Price (Can$)	Description
John Deere		**1**		**Dowels/Pinned attachment**
	AH164852	1	$5.25	Lynch pin with tether
John Deere		**1**		**Hinged/Latch attachment**
	A44990	1	$2.35	Rubber Latch
	H141549	1	$7.00	Angle
	03M7251	1	$0.13	Bolt (M6X12)
	14M7303	1	$0.25	Nut (M6)
John Deere		**1**		**Hinged/Latch attachment**
	AH167973	1	$18.50	Latch kit
John Deere		**1**		**Hinged/Latch attachment**
	H132708	1	$12.75	Mounting Bracket
	H130930	1	$9.25	Spring latch
	19M7784	1	$0.25	Cap Screw (M10X20)
	14M7296	1	$0.50	Flange nut (M10)
Case IH		**1**		**Hinged/Latch attachment**
	L105124	1	$8.22	Hook for latch
	470-11012	2	$0.68	Screw - machine, pan head slotted, No 10NC X 3/4in
	231-51409	2	$0.64	Nut - hex serrated flange, No 10 NC
	188103C1	1	$8.35	Bracket - Latch anchor
	494307C1	1	$4.32	Rubber Latch
	432-812	1	$0.74	Cotter Pin, 1/8 X 3/4in
	439-1412	1	$1.07	Pin - headed, 1/4 X 3/4in, grade 2
	439-1424	1	$1.47	Pin - headed, 1/4 X 1.5in, grade 2
New Holland		**1**		**Hinged/Latch attachment**
	350918	1	$7.71	Mounting Bracket
	353067	1	$10.98	Rubber latch
	453857	1	$5.26	Clip for latch
AGCO		**1**		**Hinged/Latch attachment**
	101232M1	1	$19.23	Stop Bracket, Guard
	101231M1	1	$27.29	Bracket, Latch
	7025075	1	$6.65	Bracket, Catch
	1787520W1	1	$3.92	Anchor bracket, Rubber latch
	776682	1	$5.36	Hook, Rubber
Note: Prices listed were at the time this guide was written (2003). See your local dealer for accurate pricing.				

Appendix VII
Farm Machinery Guarding Procedure

Farm Machinery Guarding Procedure					
Date:		**Location:**			
Machine:		**Persons performing procedure:**			
1. Risk Assessment (See Section 2.2)					
1.1 What is the Function of the Machine? (See Section 2.2.1)					
1.2 What Hazards Exist? (Check off) (See Section 2.3)					
Hazard Type	**Hazard Number and Description**				
	1: _____	**2: _____**	**3: _____**	**4: _____**	**5: _____**
A) Entanglement?					
B) Drawing-In?					
C) Pinch Points?					
D) Thrown Objects?					
E) Cutting?					
F) Shear?					
F) Impact?					
G) Crushing?					
H) Stabbing and Puncture?					
I) Friction?					
J) High-pressure injection?					
K) Heat?					
L) Electrical?					
M) Other?: _____					
1.3 Risk Estimation (See Section 2.2.3)					
A) What is the severity of possible injury? (Choices: Minor=1, Severe=5, Fatal=10)					
B) What is the probability of the injury occurring? (Choices: Low=1, Medium=5, High=10)					
C) Calculate Total Risk Rating? (Safeguard highest ratings first) (Total Risk= Severity X Probability)					
1.4 Risk Evaluation (See Section 2.2.4)					
A) Is risk reduction required? (Yes=continue, No=go to step 4)	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
B) Can guarding reduce risk? (Yes=continue No=other means of safeguarding required)	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No

2. Guard Type Selection (See Section 2.4.2)					
A) Can the guard be purchased from a dealer or wrecker? (No=continue, Yes=go to step 4)	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
B) Could the hazard be accessed more than once per year? (Yes=use movable guard type, No=use fixed guard type)	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
A) What guard classification to use?	_____	_____	_____	_____	_____
Refer to Appendix III for a selection flow chart of: Local Enclosing, Fully Enclosing, Local Distance, Fully Surrounding Distance Guard					
3. Guard Design, Fabrication, and Attachment (See Section 2.4)					
3.1 Guard Design					
A) Is viewing of the hazard required through the guard? (Yes=perforated or expanded metal, No=sheet metal, see Section 2.4.5)	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
B) Is the guard material resistant to the working environment? (Yes=Continue, No=paint or apply protective coating)	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
3.2 Guard Fabrication					
A) Is the guard durable and reliable? (Yes=continue, No=redesign to strengthen components)	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
B) Are warning signs applied? (Yes=continue, No=apply warning signs, see Appendix V)	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
C) Does the guard create any additional hazards? (No=continue, Yes=redesign to reduce risk)	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
D) Can the hazard be accessed through or around the guard? (No=continue, Yes=redesign to prevent access)	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
3.3 Guard Attachment to the Machine					
A) What attachment method is most practical in this case?	_____	_____	_____	_____	_____
Refer to Section 2.4.4 and Appendix VI for Attachment Methods: Bolted (fixed), Hinged/Latched, Hinged/Pinned, Dowels/Pinned, Sliding/Pinned, Slot+Tab/Pinned					
B) Is the guard securely fastened? (Yes= continue, No=strengthen attachment method)	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
C) Can the guard be easily removed or opened by one person? (Yes=continue, No=redesign to reduce weight or size)	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
4. Is the Machine Safe? YES / NO (No=return to step 1.2, Yes=process complete!)					

NOTE: The above information is to be used to help farm machinery owners and operators retrofit their used machinery with proper guarding. It does not replace or supersede any CSA, ASAE, OSHA, or ISO standards that are updated on a regular basis; nor is it a legal document to be used for law enforcement. Should you have any specific questions, your should consult with a Farm Safety Organization (see list of organizations on back cover of this publication) or other qualified people.

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Canadian Standards Association (CSA). *CAN/CSA-M11684-97 (R2002), Tractors, Machinery for Agriculture and Forestry, Powered Lawn and Garden Equipment - Safety Signs and Hazard Pictorials - General Principles (Adopted ISO 11684:1995).*

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Hazard Symbol Glossary

Crushing Hazard

Entanglement Hazard

Stabbing and Puncture Hazard

Drawing-In Hazard

Friction and Abrasion Hazard

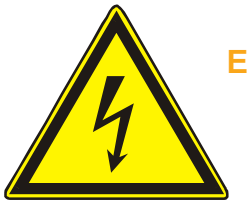
Pinch Point Hazard

High Pressure Injection Hazard

Thrown Objects Hazard

Heat Hazard

Cutting Hazard



Electrical Hazard

Shear Hazard

General Warning Hazard

Impact Hazard

Farm Safety Organizations

Canada:

Canadian Agricultural Safety Association (CASA)
Saskatoon, SK
www.casa-acsa.ca

Provincial:

Alberta
Wild Rose Agricultural Producers
Edmonton, AB
www.wrap.ab.ca

British Columbia
Farm and Ranch Safety and Health Association (FARSHA)
Langley, BC
www.farsha.bc.ca

Manitoba
Provincial Farm Safety Co-ordinator
MAFRI, and MB Labour and Immigration
Winnipeg, MB
Ph: 204/945-2315
www.gov.mb.ca/agriculture/farmsafety

New Brunswick
The Agriculture Producers Association of NB Inc.
Fredericton, NB
www.nbfarm.com

Newfoundland
Newfoundland and Labrador Federation of Agriculture
Mount Pearl, NL
www.netfx.ca/nlfa

Nova Scotia
Nova Scotia Farm Health and Safety Committee
Truro, NS
www.gov.ns.ca/nsaf/ohs/

Ontario
Farm Safety Association Inc.
Guelph, ON
www.fsai.on.ca

Prince Edward Island
PEI Federation of Agriculture
Charlottetown, PE
www.virtuo.com/peifa/

Quebec
L'Union des producteurs agricoles
Longueuil, QC
www.upa.qc.ca

Saskatchewan
Saskatchewan Alliance
Saskatoon, SK
www.iareh.usask.ca/rhep/aghealth.php

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