



ASSOCIATION OF
EQUIPMENT MANUFACTURERS



Safe Implement Hitching

A Guide for Safe Connection of Agricultural Tractors to Implements



Agriculture and
Agri-Food Canada

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NOTE

The opinions expressed in this document are those of PAMI and not necessarily the funders or advisors.

How to Use This Guide

PURPOSE

To provide information that farm machinery owners and operators can use for correctly connecting agricultural tractors to implements and other towed equipment such as wagons, grain carts, etc.

IMPORTANT



- This guide is **NOT** a substitute for the tractor and implement manufacturer's operator's manuals; it is intended to serve only as a secondary supplement to these operator's manuals or for when operator's manuals are not available.
- If you do not have an operator's manual, contact your dealer to obtain one. If they are unable to provide an operator's manual, try an internet search or check at a farm machinery museum.
- If no operator's manuals are available, use this guide along with your farm safety practices.

IMPORTANT!

This guide used information from CSA (www.csa.ca), ASABE (www.asabe.org), ANSI (www.ansi.org), OSHA (www.osha.gov), and ISO (www.iso.org) standards. However, since these standards are updated on a regular basis, readers should be aware that more current information will likely emerge. Similarly, readers should be aware that this is not a legal document to be used for law enforcement.

Should you have any specific questions, please consult with your machinery dealer.

Terminology

Proper terms relating to hitching have been developed in engineering standards over the years to provide a proper description. However, these terms may be lengthy and may not be commonly used on the farm. As a result, the more common terms will be used in the guide but explained in the following section.

Hitching – may only properly refer to the mechanical connection between tractor and implement, but in this guide, hitching will be used to describe the entire connection of all components between the tractor and implement.

Implement – normally implies only field machines such as a cultivator, baler, or air seeder, and may not normally apply to other towed equipment for material transport, such as a bale wagon, grain cart, or manure wagon. For the purposes of simplicity in this manual, the term implement will be used to cover both types of towed machines (unless specified otherwise).

IID (Implement Input Driveline) – the driveshaft (or the series of driveshafts) on implements that receive rotary power from PTOs on tractors.

PTO (Power Take-Off) – the stub shaft (usually on the rear) of tractors that transmits rotational power from the tractor to the implement.

Safety



This **Safety Alert Symbol** means: “**ATTENTION! STAY ALERT! THE SAFETY OF YOU AND OTHERS IS INVOLVED!**”

Signal Words



DANGER indicates an imminently hazardous situation, which if not avoided will result in death or serious injury.



WARNING indicates a potentially hazardous situation, which if not avoided could result in death or serious injury.



CAUTION indicates a potentially hazardous situation exists, which if not avoided may result in minor or moderate injury.



NOTICE indicates a property damage message.

IMPORTANT

IMPORTANT indicates critical information to be aware of.

Operators should stay alert to the safety signs that can be found on the tractor, on the implement, and in the operator's manuals.

Safety

Why is Hitching Safety Important?

- Accidents can injure, disable, and kill!
- Accidents can be very costly!
- Accidents can be avoided!

Think Safety First!

The SAFE connection of a tractor to an implement requires:

- Knowledge of the equipment being connected.
- An understanding of the procedures required for a safe tractor-to-implement connection.
- Operator skill.
- Respect for personal and public safety.

IMPORTANT

Before hitching a tractor to any implement, perform a hazard assessment and safety plan.

Safe Connection Procedure Summary

Risk Assessment

Risk Identification

- Does the operator have sufficient knowledge and skill?
- What hazards exist surrounding the equipment?
- Is the equipment safe and ready to operate?

Risk Estimation

- What are the potential risks to the operator, bystander, public, equipment, property?

Risk Evaluation

- What severity is associated with the risks? Death, injury, damage, cost?

Develop Safety Plan

- If any circumstances change, redo the risk assessment.



Tractor and Implement Compatibility

- Tractor power and implement power requirements
- Drawbar/three-point hitch type and category
 - pin category and condition
- PTO category
- Hydraulic and electrical requirements



Safe Connection

- Safe use of a guide/helper
- Tractor and implement alignment
- Implement precautions, safety backup, and attachment
- The primary mechanical connection
- Auxiliary connections – PTO, hydraulic, electrical



Additional Hitching Safety

- Proper tractor ballast
- Transport preparation including “walk-around inspection”

Drawbar Connection

What You Need to Know Before You Begin

Description

The drawbar type of hitch uses a single attachment point to provide the pulling force, or draft, on a drawn implement. In addition to providing the pull force on the implement, the drawbar also receives side and vertical loading from the implement.

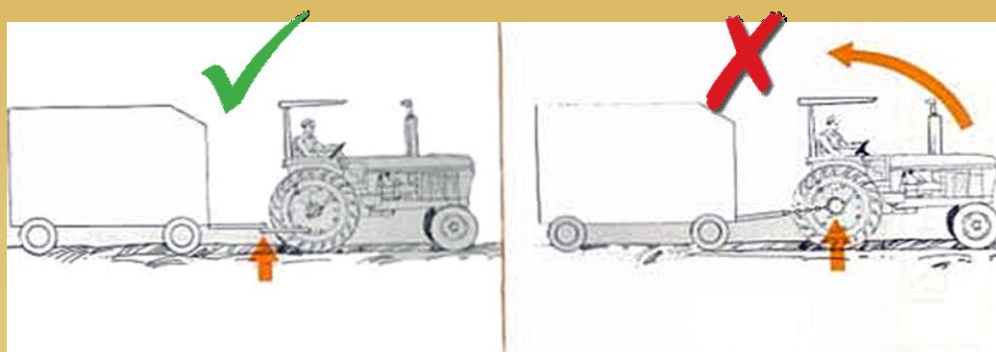
WARNING

Tractor Tip-Over Hazard

Attaching a single-point load to any location other than the drawbar, such as the axle or top link of the three-point hitch, could cause tractor rollovers that may result in death or serious injury.



The tractor drawbar is the appropriate safe location to connect a load that attaches through a single point. The drawbar is designed to ensure all pulling forces are low to minimize rear rollover risk.



- Drawbars can be either:
 - Fixed, nonadjustable.
 - Adjustable, multiple operating position drawbar providing regular, short, and extended drawbar positions.
- Tractor drawbars are now typically equipped with a factory clevis to accommodate connecting to tongue-style hitch ends of implements.
- The clevis is removable to allow for:
 - Connecting to implements equipped with a clevis.
 - Inadequate clearance between the clevis and a connected PTO shaft.

Drawbar Connection

- Tractor drawbars and pin size are categorized according to the tractor's PTO power rating.
- Drawbar pins should have a safety clip through the bottom and, ideally, an additional means to retain the pin from uploads, such as two locks.

Tractor Drawbar Categories and Pin Diameter.

Tractor Drawbar Category	Maximum Tractor PTO Power Rating		Minimum Pin Diameter	
	hp	kW	in	mm
0	38	28	1	18
1	64	48	1 ¼	30
2	154	115	1 ¼	30
3	248	185	1 ½	38
4	402	300	2	50
5	671	500	2 ¾	70

TIP

If you do not know your tractor power rating, contact your dealer or refer to the Nebraska Tractor Tests at <http://tractortestlab.unl.edu/testreports.htm>.



WARNING

Machine Runaway Hazard

Accidental implement disconnection could result in death or serious injury and/or implement damage. Use only the manufacturer's drawbar pins. Hitch pins are a special material to provide maximum strength and toughness and to minimize wear. Never use bolts or another substitute.

If the Tractor and Implement Pins are Different Sizes

For example, if a larger tractor is being used with a smaller implement, the implement pin hole may not be large enough to accommodate the tractor's pin.

Be aware of the mismatch and establish a special safety procedure, including the following:

- Use the largest pin diameter that will fit through the tractor drawbar and implement hitch.
- If the tractor is a larger category, only operate the tractor at suitable power for the implement.
- If the implement is a larger category, ensure the tractor is large enough to safely handle the implement.
- Ensure the pin will not slip through the larger clevis holes – heavy-duty large diameter washers or other alternatives may be required on the top and bottom of the pin.
- Use pins supplied by dealers or reputable farm parts suppliers – low-cost hitch pins from some sources may be of inferior strength.
- Ensure the pin is securely locked in place.
- If you encounter a mismatched tractor and implement combination, consider one of the following applicable options:
 - Modify implement hitch to match the tractor drawbar.
 - Install implement hitch or tractor drawbar hole adapters.

Retrofittable Implement
Hitch Tongue



Tractor Drawbar Hole
Size Adapter



Implement Hitch
Hole Adapter



Drawbar to Hitch Compatibility

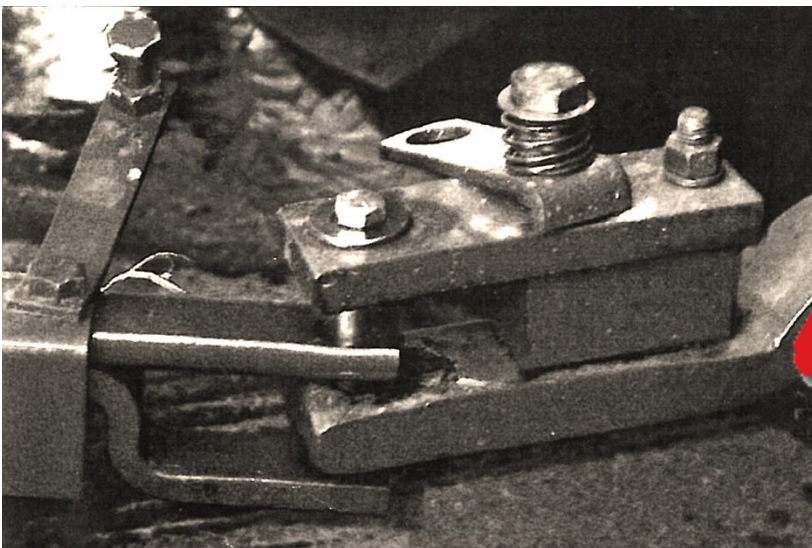
The clevis-to-tongue connection provides the most safe and stable loading of the drawbar pin while allowing the required vertical angular capabilities (pitch) and rotational capabilities (roll). Newer tractors are generally equipped with a clevis on the drawbar.

Drawbar Connection



Typical Clevis-to-Tongue Hitch Connection

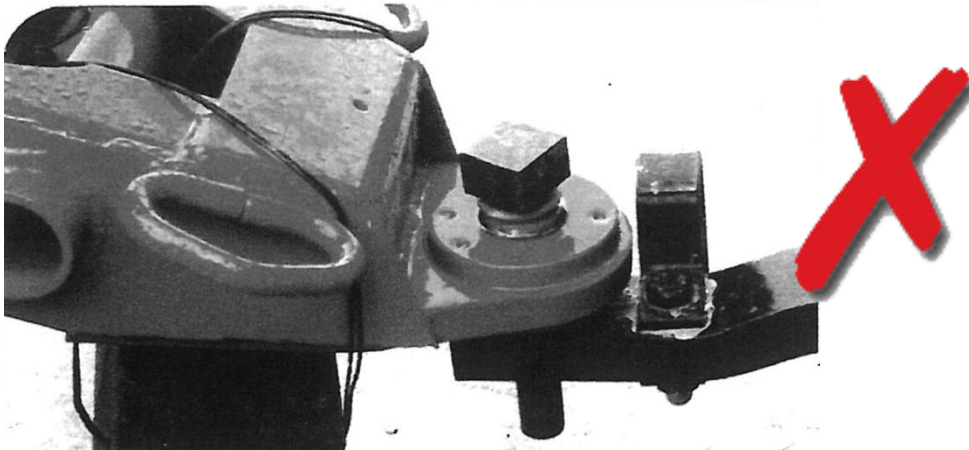
Clevis-to-clevis connections are unsafe as they can limit angular movement and put extremely high loads on the pin and other components, which can lead to mechanical failure. Convert one of the clevises to a tongue for safe connection.



Clevis-to-Clevis Hitch Connection

Drawbar Connection

Tongue-to-tongue connections are unsafe as they could easily result in accidental detachment of the implement. The tendency for a quick fix using a bolt or pin is an unsafe practice even if a retainer is used. It is recommended that the tractor have a clevis installed to achieve a safe connection.



Tongue-to-Tongue Hitch Connection

TIP

One-Person In-Cab Drawbar Hitching Systems

Hitching can be an inconvenient process if only one person is available, or it can be a process requiring extra safety measures if using a helper. However, one-person drawbar hitching systems have been developed to make one-person hitching much more convenient. These systems allow the primary mechanical connection to occur with the operator on the tractor so that only one trip is required to complete engagement of the safety locks and other nonmechanical connections.

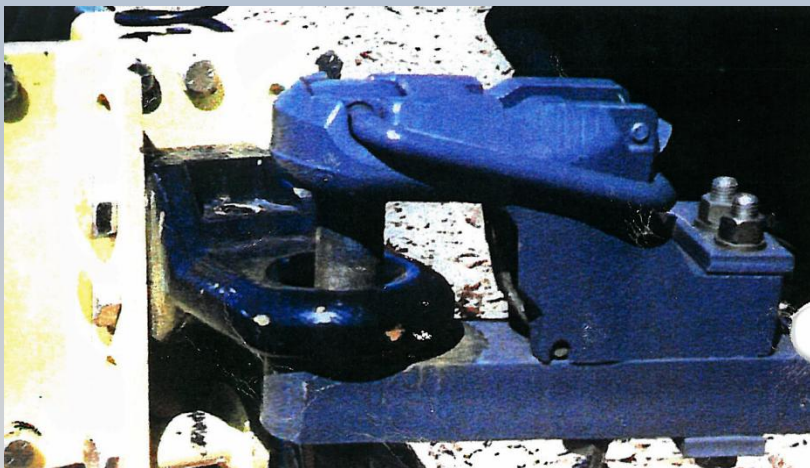


Photo Courtesy of Power Pin Hitching System

Important: Ensure these hitch attachments match your tractor hitch category!

The Drawbar Connection

Hitch Jacks

- Most implements now have hitch jacks as they are a safe, convenient method of setting the vertical position of the hitch.
- If your implement does not have a hitch jack, you may want to consider adding one. Contact your dealer to assist you with selection and installation. The selection will depend on your hitch load and the load rating of the jack (e.g. 2,000 lb [900 kg], 5,000 lb [2,300 kg], etc.).
- Recent standards specify that hitch jacks must be able to withstand a side load of 50% of the vertical load.
- Tractor operators need to back up to implements cautiously as an impact can cause machine damage. In addition to direct damage to the tractor or implement, the hitch jack could fail and lead to secondary machine damage.



NOTICE

Hitch jacks are not usually designed to take the forces of a loaded wagon, so wagons should be emptied before unhitching to prevent damage to the hitch jack.

Making the Connection

I. The Safety Plan and Walk-Around Inspection

1. Evaluate the surrounding environment – assess the ground conditions (slope, moisture, soil stability) and proximity of obstacles such as ditches, buildings, other equipment, power lines, etc.
2. Check the tractor and implement to ensure they are safe to operate. Carry out a visual inspection and any required performance checks to ensure the equipment will operate as expected. For example, the inspection should include; ensuring all guards are in place, checking condition of tires, looking for fluid leaks, testing brake and steering function, etc.
3. Analyze the “what if” scenarios that could occur if something changes during the connection procedure, such as the implement falling off its supports or components becoming repositioned.
4. Assess the compatibility of the equipment, such as power and hitch types, condition of pins and safety chain.
5. Ensure that any bystanders are well clear.
6. Adjust the implement hitch height to align with the tractor drawbar height.



The Drawbar Connection

- A hitch jack is an effective way to set implement hitch height.
 - Other alternatives are a portable jack or blocking.
 - If implement weight is negative (i.e. implement tongue is up in the air), the hitch will need to be lowered with weights onto blocking or lowered down using a mechanical device like a winch to force the hitch down.
7. If you are alone, perform the steps in Section II, but if you have a helper, perform the steps in Section III.



II. If You Are Alone:

1. Ensure that you have established a “call-back procedure” with someone.
 - A call-back procedure is where someone (who is operating alone) establishes a timeline when they will call a second person to check in (i.e. a cell phone call every two hours). If contact with the operator is not made at the predetermined time, the second person will then initiate measures to check on the safety of the operator.
2. At the slowest speed possible, back the tractor towards the implement hitch with the tractor “square” to the implement.
3. When close (approximately 1 ft [0.3 m]), stop the tractor and ensure the tractor will not move (i.e. engage the park/lock brake and/or shut off the engine and remove the key, etc.).
4. Dismount the tractor and observe relative drawbar and hitch alignment (vertical and horizontal).
 - Lower or raise the implement hitch as required using the jack (or blocking).
 - Note any horizontal misalignment.
5. Return to tractor, disengage park lock/brake, make a steering correction based on estimated side-to-side offset and slowly back up the tractor by the estimated distance.

The above three steps may need to be repeated to approach the implement in small increments to avoid impacting the implement with the drawbar.

6. After the drawbar and implement hitch holes are aligned, insert the hitch pin and install the pin positioning lock (hitch pin clip or equivalent).



III. If You Have a Helper:

1. Ensure that you have coordinated hand signals (see **Appendix I** for recommended ASABE hand signals) and maintain visual contact with each other throughout the entire process.
2. The helper should remain safely outside the path of the tractor until the tractor is stopped.
3. At the slowest speed possible, back the tractor towards the implement hitch with the tractor “square” to the implement until the tractor is close (approximately 1 ft [0.3 m]) from the implement.

The Drawbar Connection

4. Stop the tractor, ensure the tractor will not move (i.e. engage the park/lock brake and/or shut off the engine and remove the key, etc.), and signal helper that it is safe to do a close inspection for alignment.
5. The helper should lower or raise the implement hitch as required using the hitch jack (or blocking) and signal you the offsets (side-to-side and backup distance) then step out of the path of the tractor.
6. Disengage park lock/brake, and based on helper guidance, make a steering correction based on side-to-side offset and slowly back up the tractor by the estimated distance.

The last three steps may need to be repeated to approach the implement in small increments to avoid impacting the implement with the drawbar.

7. After the drawbar and implement hitch hole are aligned, the tractor should be stopped and ensure the tractor will not move (i.e. engage the park/lock brake and/or shut off the engine and remove the key, etc.).
8. The helper can then insert the hitch pin and install the positioning lock (hitch pin clip or equivalent).



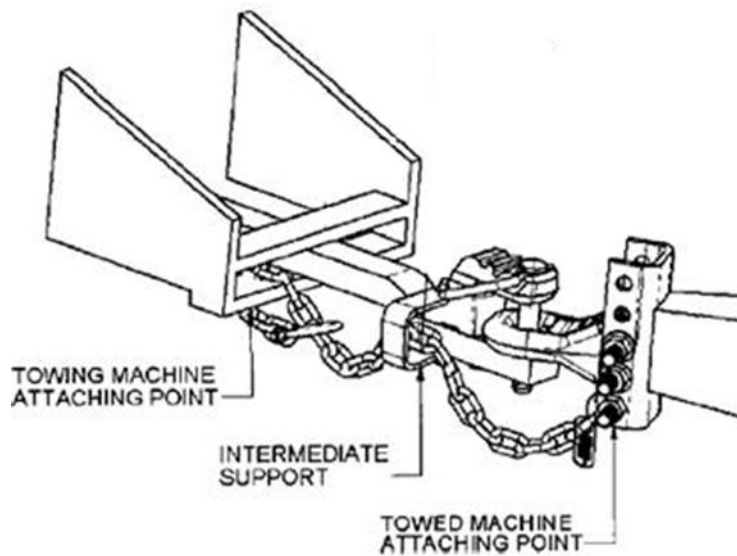
Safety Tow Chain

A safety chain(s) is a required “safety backup” for tractor-to-implement connections. The safety chain maintains connection between the implement and tractor should the primary connection fail during transport.

Safety Chain Size

- Minimum strength equal to the gross weight of the implement being towed, for implements up to 80,000 lb (36,300 kg).
- Rated at 80,000 lb (356 kN) for implements weighing over 80,000 lb (36,300 kg).
- The rating of safety chains will be marked on a metal tag and should not be detached from the chain.

The Drawbar Connection



Typical Safety Chain Attachment

Photo Courtesy of ASABE

- Attach the safety chain to secure locations on the implement hitch and tractor as shown in the schematic above. Never attach the chain to an intermediate support.
- If the distance from the drawbar pin to either the front or rear chain attachment point exceeds the values below, intermediate chain support is required.
 - For chains rated at 30,000 lb (133 kN) or less, distance cannot exceed 9 in (23 cm).
 - For chain rated at 40,000 lb (178 kN) or more, distance cannot exceed 11 in (28 cm).
- The slack in the chain should only be enough necessary for articulation.
- Ensure the safety chain(s) have not been damaged (i.e. worn from dragging, stretched, kinked, etc.)
- Chains that are not in use should be properly stored.



WARNING

Machine Runaway Hazard

Accidental implement disconnection on a public road could result in death or serious injury and/or implement damage.

NEVER tow an implement on a public road without a hitch pin retainer and a properly sized safety chain.

The Drawbar Connection

Vertical Drawbar Loading

- Significant positive (downward) or negative (upward) vertical loads can be transferred from the implement hitch to the drawbar, which can affect tractor handling characteristics. This is one reason why adequately sized tractors for the implement are recommended.
- Ideally, 10% of implement weight should be on the drawbar for optimum stability.
 - Negative (upward) drawbar loads are not recommended especially when transporting as they reduce control of your tractor.
 - Conversely, excessive drawbar positive (downward) loading should be avoided and vertical loading should adhere to the following table.
 - **Important: Avoid dynamic or shock loading by reducing speed over rough terrain.**

Tractor Drawbar Category	Maximum Tractor PTO Power Rating		Maximum Vertical Drawbar Load	
	hp	kW	lb	kN
0	38	28	1,100	5
1	64	48	1,800	8
2	154	115	3,400	15
3	248	185	4,100	18
4	402	300	4,900	22
5	671	500	6,700	30
Important Notes:				
1. The above vertical loads are based on recent engineering standards. Tractor manufactures may design for higher vertical loads. Check in your operator's manual or with your dealers.				
2. The above vertical loads are with the drawbar in the regular position. Allowable loads are increased by about 50% in the short position and reduced by about 25% in the extended position.				

Implement Storage

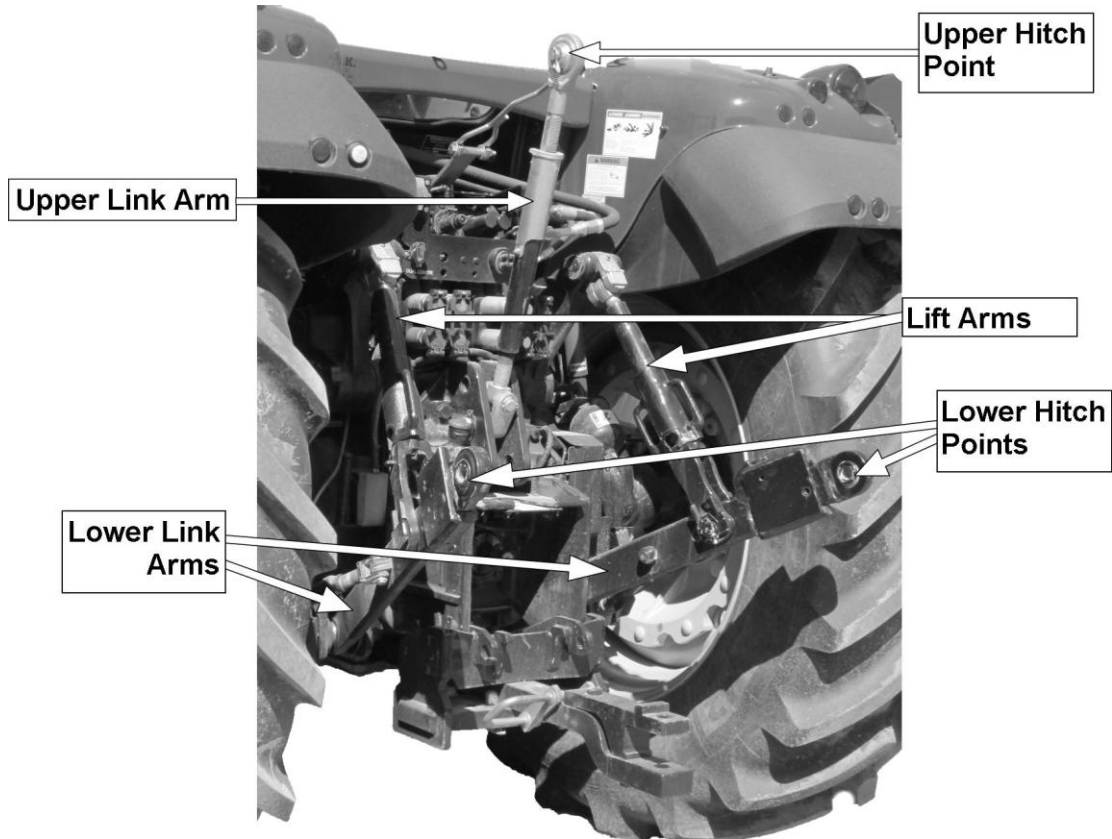
- When disconnecting and storing the implements consider the ground condition of the storage location. Choose a firm, level, and well-drained area for storing the implement to prevent the implement from rolling or sinking when disconnected from the tractor.
- Lower hitch jack (if equipped) or block the hitch.
- Block the wheels to prevent from rolling (or engage park lock/brake, if equipped).

Three-Point Hitch Connection

What You Need to Know Before You Begin

Three-point hitches on tractors provide a connection that links the implement to the tractor and keeps the implement supported and in line with the tractor at all times.

Three-Point Hitch Components



- Two Lower Links: The two arms that connect to the two lower attachment points on the implement and transfer tractor pull (draft) to the implement.
- On many tractors, the lower link can be set to different modes of operation:
 - Depth/Position Control: Draft links are positioned and remain at the height set on the control lever. **Use this setting for hitching.**
 - Float Control: Draft links are raised and lowered by the attached implement as it follows the contours of the ground without any interaction from the hydraulic system. **Do not use when hitching.**

Three-Point Hitch Connection

- Draft/Load Control: The three-point hitch is responsive to changes in the amount of draft load produced by the implement, automatically raising and lowering the height of the draft links to keep the draft on the tractor relatively constant. **Do not use when hitching.**
- The Upper Link provides the third connection point for the three-point hitch to maintain a stable tractor-to-implement connection. This link usually has a screw adjustment to shorten and lengthen the link, which can be adjusted by hand.
- Sway Chains, Sway Blocks, or Sliding/Fixed Members: Restrict side movement of draft links to prevent interference with other tractor components such as the tires.

WARNING

Machine Tip Over Hazard

A tractor rollover can result in death or serious injury.



- Never attach an implement to the three-point hitch attachment on a tractor unless the implement is designed with a three-point hitch.
 - The mass of the implement carried behind the tractor shifts the tractor's centre of gravity and can change handling capabilities and stability - proper ballasting is required
 - Operators should avoid traversing steep slopes or climbing embankments when heavy implements are being carried.
- Three-point hitch configurations are based on tractor PTO power ranges and are identified as one of five different categories. Each higher category has correspondingly larger link arms, larger diameter hitch pins, wider lower arm spacing, increased operating range, and higher lift capacity.

Three-Point Hitch Specifications

Category	Tractor PTO Power	Hitch Pin Size		Lower Arm Spacing
		Upper Link	Lower Links	
0	under 27 hp (under 20kW)	$\frac{5}{8}$ " (17 mm)	$\frac{5}{8}$ " (17 mm)	20" (500 mm)
1	up to 64 hp (48 kW)	$\frac{3}{4}$ " (19 mm)	$\frac{7}{8}$ " (22 mm)	26" (718 mm)
2	up to 123 hp (92 kW)	1" (25.5 mm)	1 $\frac{1}{8}$ " (28 mm)	32" (870 mm)
3	107 hp – 248 hp (80 kW – 185 kW)	1 $\frac{1}{4}$ " (31.75 mm)	1 $\frac{7}{16}$ " (66 mm)	38" (1010 mm)
4	201 hp – 469 hp (150 kW – 350 kW)	1 $\frac{3}{4}$ " (45 mm)	2" (51 mm)	46" (1220 mm)

NOTE: Specialized implements may have lower arm spacing and mast height dimensions that differ from the standard dimensions.

TIP

One-Person In-Cab Three-Point Hitching Systems



Hitching can be an inconvenient process if only one person is available, or it can be a process requiring extra safety measures if using a helper. Three-point hitch quick couplers are available to facilitate easy hitching. The arms are raised to engage the hooks, and the latches are engaged to lock the coupler in place. These facilitate one-person hitching. These systems allow the primary mechanical connection to occur with the operator on the tractor so that only one trip is required to complete engagement of the safety locks and other nonmechanical connections.

Important: Ensure these hitch attachments match your tractor hitch category!

In preparation for connecting the tractor to the implement, the following equipment checks should be performed on the tractor:

- **Drawbar:** Check the drawbar position to ensure it will not interfere with the draft links or any part of the implement. If necessary, move the drawbar forward and/or to the side of the hitch support assembly. Lock the drawbar in this position, or remove it completely.
- **Ballast:** Since the tractor may carry the entire weight of the implement, tractor ballast is extremely important for maintaining control.

In preparation for connecting the tractor to the implement, the following equipment checks should be performed on the implement:

- **Implement Positioning and Support:** Eliminate the need to physically manoeuvre the implement into alignment with the tractor. Use adequate blocks or jacks to position the equipment for safe and easy connection. Many implements are configured with their own stands or jacks for proper support and alignment.

Making the Connection

I. The Walk-Around Inspection

1. Evaluate the surrounding environment – assess the ground conditions (slope, moisture, soil stability) and proximity of obstacles such as ditches, buildings, other equipment, power lines, etc.
2. Check the tractor and implement to ensure they are safe to operate. Conduct a visual inspection and any required performance checks to ensure the equipment will operate as expected. For example, the inspection should include ensuring all guards are in place, checking condition of tires, looking for fluid leaks, testing brake and steering function, etc.
3. Ensure the compatibility of the equipment, such as the hitch category.
4. Ensure that any bystanders are a safe distance away.
5. Analyze the “what if” scenarios that could occur if something changes during the connection procedure, such as the implement falling off its supports or components becoming repositioned.
6. If you are alone, perform the steps in Section II, but if you have a helper, perform the steps in Section III.



II. If You Are Alone:



1. Ensure the draft link setting is on “depth control.”
2. At the slowest speed possible, back the tractor towards the implement with the tractor “square” to the implement.
3. When close, adjust the draft links to the height of the lower implement pins and ensure the tractor will not move (i.e. engage the park/lock brake and/or shut off the engine and remove the key, etc.).
4. Dismount the tractor and inspect relative link and pin alignment (vertical and horizontal).

Note the amount of misalignment.

5. Return to tractor, make any necessary lower link adjustments (up/down) and any necessary steering correction based on estimated side-to-side offset, and then slowly back up the tractor by the estimated distance.

The above steps may need to be repeated to approach the implement in small increments and avoid impacting the implement with the tractor links.

TIP

If your tractor has telescoping draft links, they may provide adequate travel so that tractor repositioning is not required.

Three-Point Hitch Connection

6. After the draft link holes and implement pins are aligned, slide the lower arm holes onto the pins (this will usually require adjustment or temporary removal of the antisway bars or chains).
7. Install the retainer clips on the pins.
8. Next, align the top link hole with the top pin (this can usually be done by turning the threaded adjustment on the top link). Insert pin and install pin retainer.



III. If You Have a Helper:

1. Ensure that you have coordinated hand signals (see **Appendix I** for recommended ASABE hand signals) and maintain visual contact with each other throughout the entire process.
2. The helper should remain safely outside the path of the tractor while the tractor is moving.
3. At the slowest speed possible, back the tractor toward the implement hitch with the tractor “square” to the implement until close (approximately 1 ft [0.3 m]) to the implement.
4. Stop the tractor, ensure the tractor will not move (i.e. engage the park/lock brake and/or shut off the engine and remove the key, etc.), and signal helper that it is safe to do a close inspection for alignment.
 - The helper should signal the offsets to the operator (up and down, side-to-side, and backup distance) then step out of the path of the tractor.
 - Based on helper guidance, make any necessary lower link and steering correction slowly backing the tractor by the estimated distance.
 - Stop the tractor, ensure the tractor will not move (i.e. engage the park/lock brake and/or shut off the engine and remove the key, etc.), and then signal helper that it is safe to do a close inspection for alignment.
 - This step may need to be repeated to approach the implement in small increments and avoid impacting the implement with the tractor links.
5. After the draft link holes and implement pins are aligned, slide the lower link holes onto the pins. This will usually require adjustment or temporary removal of the antisway bars or chains.
6. Install the clips on the pins.
7. Align the top link hole with the top pin (this can usually be done by turning the threaded adjustment on the top link) and install the pin and pin retainer.



TIP

If your tractor has telescoping draft links, they may provide adequate travel so that tractor repositioning will not be required.



Three-Point Hitch Connection

TIP

Make sure the draft and center link connecting holes fit snug over the implement hitch pins. If the fit is not correct, it is likely that the tractor and implement have different category hitch dimensions. If the implement pins are too small, you may be able to install correctly sized adapter bushings on the hitch pins to achieve the snug fit.



WARNING

Machine Runaway Hazard

Accidental disconnection of an implement can result in death or serious injury and equipment damage. Use proper retaining clips or pins to secure the hitch links at all three pinned connections. A bolt or a piece of wire is not a suitable pin retainer.

After the Hookup

- After the implement is properly connected, slowly raise and lower the implement to check for any interference between the tractor and implement.
- Prior to beginning any field operations, the following should also be checked:
 - Implement levelling.
 - Implement rate-of-drop control.
 - Implement side sway adjustment.
 - Upper center link adjustment for proper draft control sensing (if tractor is equipped).
- Always lower the implement to the ground, shut off the engine, and remove the key whenever temporarily leaving the tractor and implement.

Implement Storage

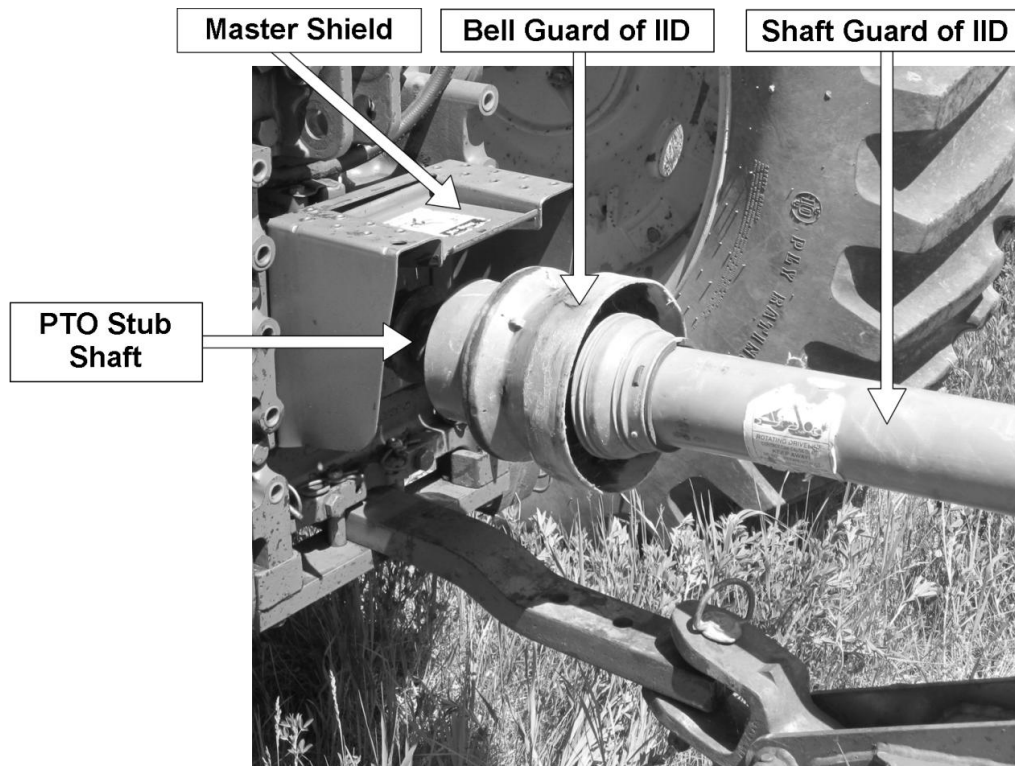
When disconnecting and storing three-point hitch implements consider:

- Ground condition of storage location: Choose a firm, level, and well-drained area for storing the implement to prevent the implement from rolling or sinking when disconnected from the tractor.
- Block lower support/jack stands (if equipped), or implement: Support the implement on blocks, or lower manufacturer-supplied support stands prior to disconnecting the implement to prevent any tipping of the implement.

Power-Take-Off (PTO) Connection

What You Need to Know Before You Begin

- The power-take-off (PTO) of the tractor transfers rotational power to PTO-driven implements through the implement input driveline (IID).



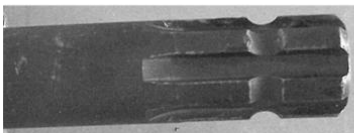
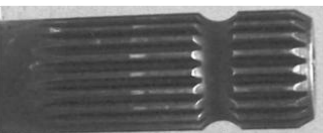
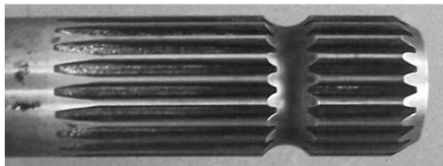
- Manufacturers size the individual components in a driveline to transmit the required power and also design in the necessary safety features such as shielding and proper telescoping for turning and going up and down hills.
- Agricultural PTOs are configured to rotate either at 540 rpm or 1,000 rpm.

Power-Take-Off (PTO) Connection

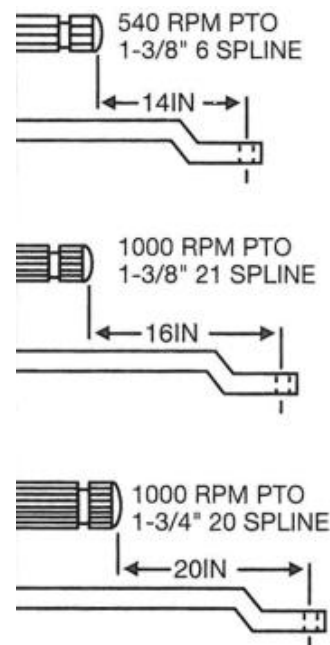
- When viewed from the rear of the tractor, the tractor's rear-facing PTO will rotate clockwise. A front-mount PTO when viewed from the front also rotates clockwise. Thus implement drivelines will rotate correctly regardless of which PTO is attached. This is a built-in safety feature to prevent implements from being accidentally run backwards.
- The tractor master shield covers the area on top and on the sides of the PTO stub shaft. The master shield, or a portion of it, may be configured to temporarily hinge out of position to allow easier connection of the implement driveline to the PTO stub shaft.
- PTO stub shaft guards are used to enclose the stub shaft when the tractor PTO is not being used.



Three standardized PTO stub shaft configurations exist based on shaft diameter, number of splines, and shape of spline.

Type 1	Type 2	Type 3
540 rpm	1,000 rpm	1,000 rpm
		
6 Spline 1-3/8" diameter	21 Spline 1-3/8" diameter	20 Spline 1-3/4" diameter

- Drawbar Position: The horizontal distance should be set so the hitch pin is centered between the two U-joints of the implement driveline on implements with equal angle drivelines.
- Implements with constant velocity (CV) drivelines may not require this.
- 540 rpm and 1,000 rpm implements may require different drawbar positions.
- Refer to the implement operator's manual for the correct drawbar length. Typical drawbar lengths are shown to the right.



Power-Take-Off (PTO) Connection

Know Your Tractor

- Tractors use different methods for engagement and control of the PTO depending on the year, make, or model of the tractor.
- Tractors may be configured with a reversible PTO stub shaft to permit switching between 540 rpm and 1,000 rpm output.
- On older tractors, some PTOs when engaged run only if the tractor clutch is also engaged. The PTO will stop each time the clutch is disengaged. Later tractor models have the PTO driven directly and are often referred to as “independent” or “live” PTOs. They engage and disengage through their own dedicated engagement mechanism unrelated to clutch position.
- Ideally there should be a safety mechanism built into the tractor to prevent the over-speeding of a 540 rpm PTO. If there is no safety mechanism, operators must take special precautions (such as knowing associated tachometer speed) to prevent over-speeding implements designed to run at 540 rpm.
- A few tractors have a two-speed PTO shifter that provides either 540 rpm or 1,000 rpm, usually without interchanging the PTO shaft. These typically have the 1-3/8 in – 6-spline output shaft. This design was not intended to provide higher implement speed than provided by the 540 rpm setting, but rather to allow the tractor engine to operate at much lower speed than its rated speed. This was specifically for low power requirement operations to provide fuel savings obtained from lower engine speed operation.
- Ensure that you are aware of the engine rpm that corresponds to your 540 rpm and 1,000 rpm PTO so you always run PTOs at the correct speed.

WARNING



Implement Driveline Over-Speeding Hazard

Implement driveline failure could lead to death or serious injury and/or equipment damage.



Do NOT use PTO adapters for the following reasons:

- If an implement that is designed for 540 rpm is run at 1,000 rpm, implement damage from over-speeding the implement driveline can occur.
- If an implement that is designed for 1,000 rpm is run at 540 rpm, implement damage from excessive torque on the implement driveline can occur.
- The coupling between the tractor PTO and implement driveline shaft may no longer be guarded.
- The implement driveline U-joints may no longer be centered over the hitch pin which will result in vibration on turns and premature failures.
- The telescoping portion of the implement driveline is shortened, which may cause the drive shaft to “bottom out” on turns and become damaged.

Power-Take-Off (PTO) Connection

Know Your Implement

- **Rotational Speed:** PTO-driven implements may be available with either 540 rpm or 1,000 rpm drivelines. An implement or machine configured with a 540 rpm driveline should not be connected to a 1,000 rpm tractor PTO, nor should a 1,000 rpm implement driveline be connected to a 540 rpm tractor PTO. To change operating speed of an implement requires gear case changes. Changing only the implement driveline will not convert the implement from one PTO speed to the other.
- **Recommended Implement Driveline:** The implement driveline on PTO-driven implements is specifically configured to meet the implements operating requirements, satisfying various requirements such as cross-sectional diameter, U-joint spline configuration, and telescoping length.

NOTICE

To prevent shaft failures, only use the implement driveline recommended by the manufacturer – never switch or substitute an alternate implement driveline in place of the recommended implement driveline.

- **Implement Driveline Mechanical Condition:** A worn or damaged driveline component should not be used. Replace a damaged driveline or driveline components with only approved parts.
- **Implement Driveline Alignment:** For implement drivelines that can be separated or pulled apart when reconnecting, the U-joints at the ends of the implement driveline must be correctly aligned, or in phase, to prevent excessive vibration and strain on the driveline components. The correct alignment requires the end yokes of the U-joint to be positioned in the same plane.



U-joints “in Phase”

- **Implement Driveline Overload Devices:**
 - Make sure manufacturer recommended shear pins are used and installed correctly, and that proper replacement shear pins are readily available if one fails.
 - Slip clutches and other overload devices should be checked for correct operation.
- **Implement Driveline Guards:** Make sure all the required implement driveline guarding components are in place, in good condition, and will function to provide the

Power-Take-Off (PTO) Connection

necessary protection. Replace any missing or damaged guarding components prior to using the PTO-driven implement.

- The type of implement driveline guarding will vary depending on the age of the implement. Older implements may have inverted u-shaped metal covers over the implement driveline. Caution should be used with this guarding as it is not as effective as the newer equipment that has fully enclosed implement driveline guards.
- Implement Driveline Splines:
 - Some implements may be available with either 1-3/8" (35 mm) or 1-3/4" (44 mm) diameter 1,000 rpm drivelines.
 - Clean any paint, dirt, old grease, or other debris from the implement driveline U-joint splines.
 - Apply a small amount of grease on the clean splines to assist with sliding the implement driveline U-joint onto the tractor PTO stub shaft.

Making the Connection

The Walk-Around Inspection

- Ensure the tractor has adequate power, operates at the correct PTO speed, and that the splines are compatible.
- For drawbar connections, lock the drawbar in a position that is directly below the PTO stub shaft so that the centerlines of both are aligned.
- When the tractor is also equipped with a three-point hitch, it may be necessary to remove the draft links to prevent interference with the implement driveline and/or implement hitch, particularly when turning.
- For three-point hitch connections, move the drawbar to a position that will not interfere with the implement or three-point hitch. Remove the drawbar if necessary.
- Verify that the implement driveline shaft guard can freely rotate independent of the driveline shaft. Worn, dirty, or damaged implement driveline guarding may not provide protection. Replace ineffective guarding and never trust guarding to provide complete protection.

WARNING

Entanglement Hazard



Accidental entanglement in the PTO or implement driveline could result in death or serious injury. Do NOT attempt to connect an implement driveline to the tractor PTO while the tractor engine is running!

- Set park lock/brake.
- Shut off engine, remove key, and do not start until connection is complete.



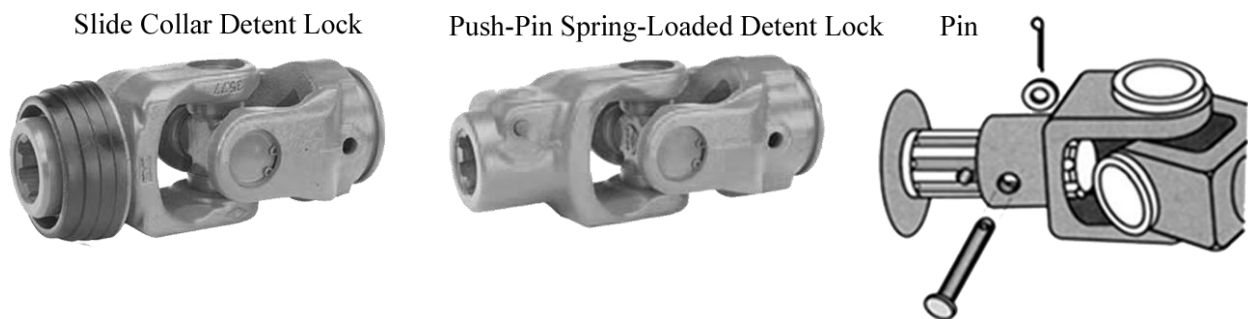
Hookup

- Support the weight of the implement driveline by cradling it in your hand around the integral shaft guard. Do not lift the implement driveline by the end bell guard as this can damage the guard.
- Align the implement driveline U-joint splines with the tractor PTO stub shaft splines. If the splines will not align, try turning the PTO stub shaft or the implement driveline slightly to get the splines aligned.
- Slide the implement driveline U-joint onto the tractor PTO stub shaft until the implement driveline locking mechanism is aligned/engaged. Self-locking collars or push-pin detent locks may have to be disengaged first to allow the implement driveline to slide onto the stub shaft. Ensure the PTO is locked in place prior to engaging or transporting the implement. Verify the implement driveline has locked onto the stub shaft by pulling back and forth on the implement driveline.

There are several methods to retain the implement driveline on the PTO.

- Currently the slide collar is the most common and preferred retainer.
- The spring-loaded detent was developed before the slide collar and is still commonly found.
- A pin retainer is only used on older equipment. On these retainers, it is important to be sure the pin is as short as possible to prevent it from snagging anything.

Power-Take-Off (PTO) Connection



Types of PTO Retainers

- Return and lock the tractor master PTO shield in its required guarding position if it was pivoted out of the way to allow connection of the implement driveline to the tractor PTO stub shaft.
- Attach the implement driveline guard retaining chain (if equipped) to a fixed point on the tractor.

After Hookup

- The implement driveline should run as level as practical and the vertical distance between the top of the drawbar pin and the implement driveline shaft should be at least 4 in. (100 mm) (*newer tractors are designed to have adequate clearance but older tractors may not and may require repositioning or removing the drawbar if the tractor is equipped with a stepped or bent drawbar*).
- Implement driveline shaft overlap must be adequate for power transmission and to accommodate turning and angular changes.
- Tractor wheels must not be allowed to contact an implement driveline.
- Any type of foreign material must not be allowed to wrap on the implement driveline.
- The tractor PTO should not be routinely disengaged at high idle, if the tractor has a PTO brake and the implement does not have an overrunning clutch, to avoid driveline damage.
- If not connected during transport, the implement driveline must be securely stored so as not to interfere with the implement or tractor.

Hydraulic Connections

What You Need to Know Before You Begin

- Hydraulic power has become very popular to provide various implement operations for various functions such as raising and lowering the implement, providing rotational power, or engaging mechanisms.
- For many years, hydraulic connectors have been standardized so that all implement hydraulic lines can be coupled to all tractor hydraulic outlets.



Standard Hydraulic Coupler

- Agricultural tractor hydraulics normally operate in a range from 2,100 psi to 3,600 psi (145 bar to 250 bar) depending primarily on age and size of the tractor. Only properly rated hoses, pipes, and fixtures should be used.
- Hydraulic oil under pressure can pose a serious health and safety risk if not handled properly. The skin and eyes must always be protected from escaping hydraulic fluid under pressure.
- Before disconnecting hydraulic lines or fittings, ensure the pressure has been released from the system.
- Before applying pressure to a system, ensure all hoses and fittings are not damaged and all connections are tight.
- If injured by escaping fluid, seek medical attention immediately. Serious reaction or infection can occur if the appropriate medical treatment is not administered.

WARNING

Fluid Injection Hazard

Accidental injection of high-pressure oil into the hands or body could result in death or serious injury. Be cautious when checking hydraulic leaks as pressurized hydraulic fluid has enough force to penetrate skin causing serious personal injury.



- Relieve pressure in hydraulic circuit and ensure the tractor engine is turned off.
- Wear proper hand and eye protection.
- Examine the hydraulic hose in the vicinity of the leak for breaks or cracks.
- Repair or replace hydraulic lines per manufacturer's recommendation.

Note: If the leak cannot be detected by this method, an option is to use a piece of cardboard to locate fine sprays. Use this practice with caution. Wear proper hand and eye protection and be absolutely sure that the cardboard is long enough so your hand is far from the hazard and will never be accidentally injected with oil.

Making the Connection

Hookup

- Before connecting, clean both the male and female portion of each fitting or mating components. Contaminants cause premature wear, damage, blockage, leakage, and affect the operation of certain implement functions that can lead to safety issues.
- Recognize that when an implement is disconnected, the hydraulic lines may still be under high pressure. The pressure should not be relieved by impacting the tip of male coupler. The escaping oil is a safety hazard and may cause serious injury.
- Wear gloves and push implement male fittings into the female fitting on the tractor. Some may require the collar on the female fitting to be pushed back concurrently until the male is fully engaged.
- The tractor hydraulic controls should not be operated before all circuits have been completely connected. Pressuring one side of a circuit without a return path may overload components. It is also important to remember that when implement safety lock devices are engaged, the hydraulic controls must be operated with caution to ensure the lock components are not damaged.
- Most tractor hydraulics will allow the implement fittings to be connected even if the hoses are under pressure. Leaving an implement with pressure in the hoses is a dangerous practice. Temperature change can expand oil and increase system pressure. This could potentially lead to a failure of a hose, fitting, valve, or cylinder

Hydraulic Connections

and result in the implement or a component to move unexpectedly, creating a potentially hazardous situation. It is best to engage implement safety locks or lower the equipment to the ground before disconnecting the hydraulics.

After Hookup

- The hydraulic system must not be operated until the implement has been mechanically connected (drawbar or three-point hitch connection) to the tractor. Operating the hydraulics can cause the implement to become unstable, allowing hitches or other components to move unexpectedly and create a safety hazard.
- Once connected, the hydraulic circuits must be tested to ensure that components move as expected (direction and rate of movement). Many tractors have convenient adjustments to set desired flow for recommended implement operation.
- Hydraulic cylinders connected in series will, from time to time, become what is termed “out of phase.” To synchronize the cylinders, the actuator valve must be held open for a few seconds after the cylinders have reached the end of their stroke.
- When disconnecting an implement, first lower the implement to its working position or engage the implement’s safety locks and then relieve the hydraulic pressure before disconnecting the hoses. Note that with some tractors the hydraulic controls no longer function once the engine has stopped, so the pressure must be relieved while the hydraulics are operative.

Transporting

- During transport, it is important the implement transport safety locks/stops are engaged to ensure that hydraulic components cannot accidentally move or be activated in a manner that causes loss of tractor control or the implement interfering with traffic.
- Manufacturers are beginning to integrate lockout systems that prevent hydraulic activation when the tractor and implement are operating in a transport mode. This safety feature prevents the operator from accidentally operating a hydraulic function.

Maintenance

Safe and effective functioning of the hydraulic system requires proper maintenance of the system. Key maintenance activities should include:

- Keep hydraulic reservoirs at the proper fill level.
- Avoid mixing different hydraulic oils.
- Keep oil from being contaminated with foreign substances (water, dirt, etc.).
- Prevent hoses, fittings, and valves from being damaged. Hoses must be well supported, and not kinked, pinched, or show signs of abrasion.
- Prevent the polished cylinder shafts from being contacted and potentially scratched. Scratched shafts can damage the cylinder oil seals and cause high-pressure oil leaks leading to safety hazards.

Hydraulic Connections

- Note: Both ends of hydraulic cylinders are typically pinned and must be able to move freely to prevent binding and bending the shaft. Bent or damaged shafts will damage the cylinder oil seals and cause high-pressure oil leaks.



WARNING

Crushing Hazard

Failure to properly secure machine components before servicing could result in death or serious injury. Never attempt to remove a cylinder or hydraulic fitting until all pressure is relieved and associated components are securely locked to prevent movement.

Electrical Connection

What You Need to Know Before You Begin

- On many implements, the electrical connection only provides operation of safety lighting (marker lights, warning lights, signal lights, tail lights, etc.).
- Newer implements are integrating other operating functions that are electrically powered.
- SAE J560 standard seven-pin electrical connector is the industry standard. These connectors can be obtained from any agricultural equipment dealer.



Implement Plug (male) and Tractor Receptacle (female) Seven-Conductor Electrical Connector

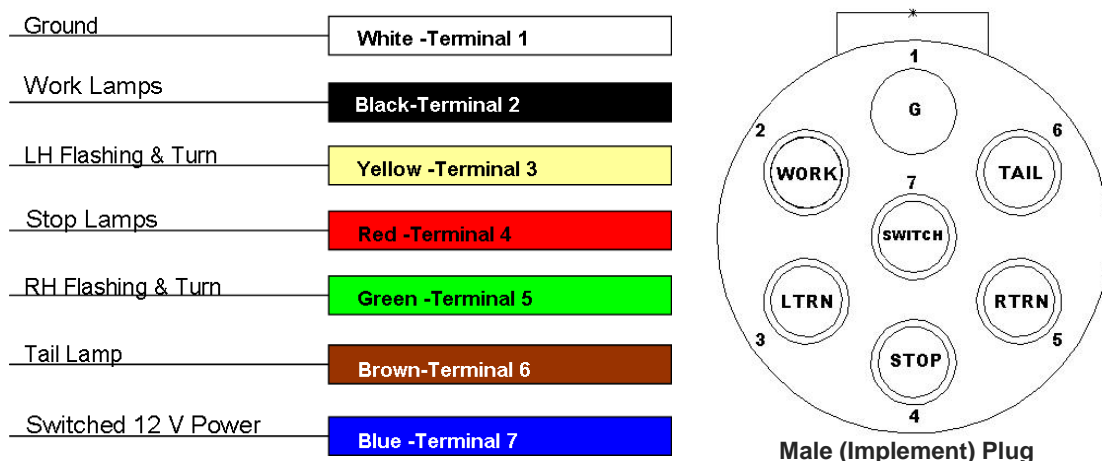
- The male connector plug (with seven sockets) is installed on the implement. The female connector receptacle (with seven pins) is installed on the tractor.

TIP

Retrofit older tractors with the seven-pin electrical connector to ensure proper light and other electrical operating functions on all implements used with those tractors.

Electrical Connection

- The wiring diagram details the industry standardized wiring connections used on manufactured agricultural machinery.



- Harness routing must minimize sharp bends, sagging, avoid sharp edges and pinch points, and should not be exposed to excessive flexing, rubbing, or exposure to oil or water.

Making the Connection

- Inspect the harness for wear and repair any worn areas.
- Turn off any implement monitors in the tractor to prevent any possible damage to the monitors.
- Ensure the male end from the implement matches the female end on the tractor.
- Clean any dirt or foreign objects from both ends.

TIP

Spray the contacts on both ends with electrical contact cleaner or apply a dielectric grease.

- Align the inner mating slides and slide the connections together.
- Ensure the catch on the female connector cap is retaining the male end.
- Check the routing of the wiring harness from the implement to the tractor to ensure that the harness is well supported to minimize sagging, prevent contact with moving components, and prevent tangling, yet allow it to flex during turning without pulling tight.
- Check all lighting on both the tractor and implement before going on any public road.

Additional Hitching Safety

Tractor Implement Stability and Ballasting

It is important that the tractor be properly ballasted. Ballast consists of ensuring the tractor has sufficient weight and proper weight distribution.

- Although ballast may be needed to counterbalance certain loads, it also plays an important role in achieving uniform traction, preventing excessive wheel slip, and preventing “wheel hop” when the tractor is pulling hard.
- There are several means of ballasting. Fluid ballast (weight) consists of filling the tractor tires with a fluid such as calcium chloride. Other options include metal (cast iron) weights that can be added to the wheels (attached to the axle or rims) and cast iron “suitcase” weights that can be hung on brackets, usually at the front of the tractor.
- Improper ballast can also have a negative effect. Over ballasting (too much weight or in the wrong place) can overload tractor components, use extra fuel and engine power that results in poor performance such as sluggish engine response when under load, difficulty starting under load, and may cause extra wear and strain on critical drive components.
- Ballasting is best done by qualified technicians who have the proper tools, relevant guidelines, and personal experience.
- For information, the following table provides approximate weight distribution guidelines, but always follow the tractor operator’s manual to properly ballast your tractor:

Tractor/Implement Type	Weight Distribution	
	Front	Rear
Two-Wheel Drive, Trailing Implement	25%	75%
Two-Wheel Drive, Semi-mounted Implement	30%	70%
Two-Wheel Drive, Mounted Implement	35%	65%
Front-Wheel Assist, Trailing Implement	40%	60%
Front-Wheel Assist, Mounted Implement	45%	55%
Four-Wheel Drive, Trailing Implement	55%	45%
Four-Wheel Drive, Mounted Implement	60%	40%

Additional Hitching Safety

Other factors for attaining tractor stability and handling include wheel spacing, tire selection, tread pattern alignment, and tire inflation. The operator must consult the tractor operator's manual and/or their dealer to resolve stability or handling problems.

Note: Operators should also be aware that some tires can develop a "set" if they have been sitting in one position for an extended period of time. When the tractor is operated at transport speed, the tractor may begin to "hop" and it may be difficult to control the tractor. The solution is to slow to a safe speed and operate for a few minutes until the tires become flexible, then gradually increase speed until the "hop" has disappeared.

Transport Safety

- Avoid transporting implements on public roads during heavy traffic times, or when visibility is reduced due to weather or time of day.
- Walk-Around Inspection: Prior to transporting equipment on a public roadway, conduct a walk-around inspection checking the tires, lights, brakes, all connections including safety chain, etc.
- Transport Locks: Ensure all implement transport locks are engaged.
- Road Width: Operators must be aware that with additional wheels on their tractor, such as duals or triples and when towing large implements, that they will take up an extended portion of many roads. This means that consideration must be given to traffic legislation, making room for oncoming traffic, and for the fact that other vehicle operators may not recognize the danger associated with large slower moving equipment.
- Lighting and Marking: Ensure that equipment meets the lighting standards in the jurisdiction where it is being transported. Being visible day and night is extremely important. A sample guide is available at the following website.
(<http://www.pami.ca/beseenbesafe/beseen/beseenchoice.htm>)
- SMV: Slow moving vehicle signs should be attached to the implement in a location that is clearly visible from the rear.
- It is also important that whenever transporting implements that the drawbar be pinned to prevent it from swinging side-to-side. A swaying implement can cause the tractor to become difficult to steer and control.
- Wide and long implements respond quickly to steering movements and in the opposite direction of the front of the tractor. This can swing the implement in the direction of an obstacle that the driver may be trying to avoid.



Additional Hitching Safety

- **Roadway Speed:** Maximum speed must be based upon the permitted road speed in the implement operator's manual, the SIS, or any decals. Speed may also be determined by the rating of implement tires, spindles and hubs, transport height, width, road conditions, and the weight of the towed implement. Unless otherwise marked, most older implements are not designed to exceed 16 mph (25 km/h).
- New tractors and implements that travel between 25 mph to 38 mph (40 km/h to 65 km/h), where required by law, will display a speed identification symbol (SIS) with their maximum allowable travel speed.



WARNING

Machine Runaway Hazard

Operating tractors and implement at unsafe speeds on public roads could result in death or serious injury. New tractors can travel at speeds that are too fast for many implements. Operators must operate at safe transport speeds.

Braking System

Always lock the left and right tractor wheel brakes together when transporting. A sudden application of a single wheel brake during transport can cause the tractor to swerve and lose control.

For Implements Without Brakes

- The loaded implement may not exceed 1.5 times the tractor weight unless the implement weight is less than 3,300 lb (1.5 t).
- Do not exceed 20 mph (32 km/h) or the speed recommended by the implement manufacturer.

For Implements With Brakes

- The loaded implement may not exceed 4.5 times the tractor weight.
- If the loaded implement is under 3 times the tractor weight, do not operate over 32 mph (50 km/h) or above the speed recommended by the implement manufacturer.
- If the loaded implement is between 3 and 4.5 times the tractor weight, do not operate at speeds over 25 mph (40 km/h) or above the speed recommended by the implement manufacturer.

Appendix I

Hand Signs

(Courtesy of ASABE)

ANSI/ASAE S351 DEC01

Approved DEC 1982; reaffirmed MAR 1998 by American National Standards Institute

Hand Signals for Use in Agriculture

Proposed by the Tractor and Machinery Committee of the National Institute for Farm Safety; approved by the ASAE Power and Machinery Division Standards Committee; adopted by ASAE as a Recommendation February 1972; reconfirmed December 1976; reclassified as a Standard December 1978; reconfirmed December 1981; approved as an American National Standard December 1982; reconfirmed December 1986; December 1991; reaffirmed by ANSI September 1992; reaffirmed by ASAE December 1996; reaffirmed by ANSI March 1998; reaffirmed by ASAE for five years December 2001.

1 Purpose and scope

1.1 This Standard provides for hand signals to be used in agriculture

operations especially when noise or distance precludes the use of normal voice communication.

1.2 The purpose of the hand signals is to provide an easy means of communication, particularly in the interest of safety.

2 General

2.1 These hand signals are in general agreement with U.S. Army Field Manual, FM21-60, Section II, Standard Arm and Hand Signals. Many of them are also used in construction and other industries where noise or distance precludes the use of voice communications.

3 Hand signals (Figs. 1-11)

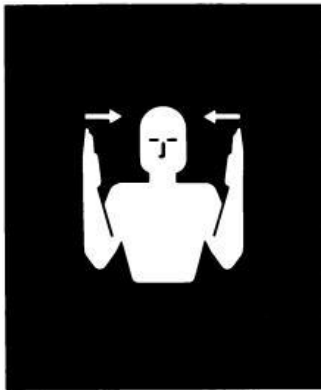


Figure 1 – THIS FAR TO GO – Place palms at ear level facing head and move laterally inward to indicate remaining distance to go.



Figure 2 – COME TO ME – Raise the arm vertically overhead, a palm to the front, and rotate in large horizontal circles.



Figure 3 – MOVE TOWARD ME – FOLLOW ME – Point toward person(s), vehicle(s), or unit(s), beckon by holding the arm horizontally to the front, palm up, and motioning toward the body.

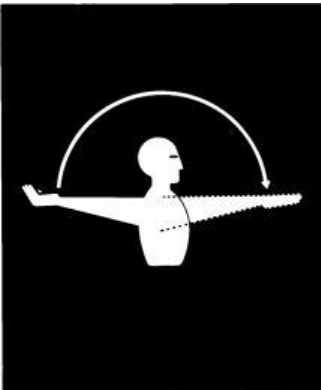


Figure 4 – MOVE OUT – TAKE OFF – Face the desired direction of movement; hold the arm extended to the rear; then swing it overhead and forward in the direction of desired movement until it is horizontal, palm down.



Figure 5 – STOP – Raise hand upward to the full extent of the arm, palm to the front. Hold that position until the signal is understood.

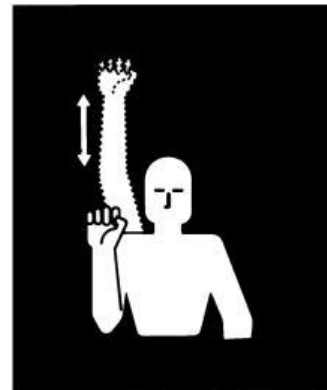


Figure 6 – SPEED IT UP – INCREASE SPEED – Raise the hand to the shoulder, fist closed; thrust the fist upward to the full extent of the arm and back to the shoulder rapidly several times.

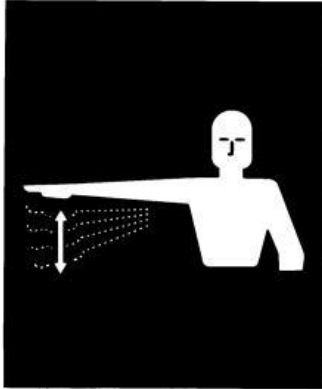


Figure 7 – SLOW IT DOWN – DECREASE SPEED – Extend the arm horizontally sideward, palm down, and wave arm downward 45 deg minimum several times, keeping the arm straight. Do not move arm above horizontal.

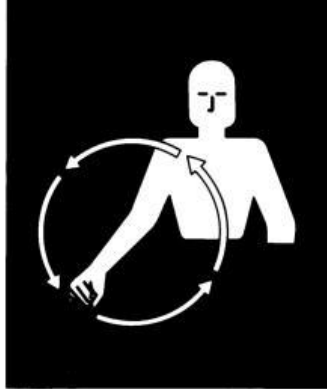


Figure 8 – START THE ENGINE – Simulate cranking of vehicles by moving arm in a circular motion at waist level.

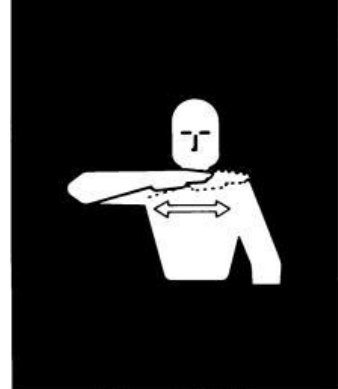


Figure 9 – STOP THE ENGINE – Draw right hand, palm down, across the neck in a "throat cutting" motion from left to right.

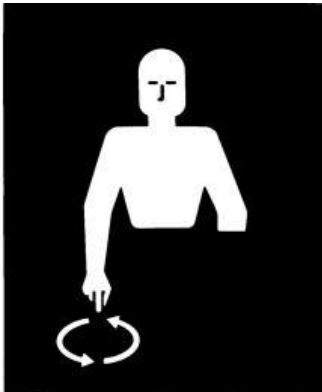


Figure 10 – LOWER EQUIPMENT – Make circular motion with either hand pointing to the ground.



Figure 11 – RAISE EQUIPMENT – Make circular motion with either hand at head level.

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