Read the operator manual entirely. When you see this symbol, the subsequent instructions and warnings are serious - follow without exception. Your life and the lives of others depend on it!
Machine Identification

Record your machine details in the log below. If you replace this manual, be sure to transfer this information to the new manual.

If you or the dealer have added options not originally ordered with the machine, or removed options that were originally ordered, the weights and measurements are no longer accurate for your machine. Update the record by adding the machine weight and measurements with the option(s) weight and measurements.

<table>
<thead>
<tr>
<th>Model Number</th>
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<tr>
<td>Serial Number</td>
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Dealer Contact Information

Name: ____________________________
Street: __________________________
City/State: ______________________
Telephone: ________________________
Email: __________________________
Dealer's Customer No.: ______________

⚠️ WARNING: Cancer and Reproductive Harm - www.P65Warnings.ca.gov
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Printed in the United States of America
Important Safety Information

Look for Safety Symbol

The SAFETY ALERT SYMBOL indicates there is a potential hazard to personal safety involved and extra safety precaution must be taken. When you see this symbol, be alert and carefully read the message that follows it. In addition to design and configuration of equipment, hazard control and accident prevention are dependent upon the awareness, concern, prudence and proper training of personnel involved in the operation, transport, maintenance and storage of equipment.

Be Aware of Signal Words

Signal words designate a degree or level of hazard seriousness.

DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury. This signal word is limited to the most extreme situations, typically for machine components that, for functional purposes, cannot be guarded.

WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury, and includes hazards that are exposed when guards are removed. It may also be used to alert against unsafe practices.

CAUTION indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. It may also be used to alert against unsafe practices.

Prepare for Emergencies

▲ Be prepared if a fire starts
▲ Keep a first aid kit and fire extinguisher handy.
▲ Keep emergency numbers for doctor, ambulance, hospital and fire department near phone.

Be Familiar with Safety Decals

▲ Read and understand “Safety Decals” on page 6, thoroughly.
▲ Read all instructions noted on the decals.
▲ Keep decals clean. Replace damaged, faded and illegible decals.
Wear Protective Equipment

Great Plains advises all users of chemical pesticides or herbicides to use the following personal safety equipment.

- Waterproof, wide-brimmed hat
- Waterproof apron.
- Face shield, goggles or full face respirator.
- Goggles with side shields or a full face respirator is required if handling or applying dusts, wettable powders, or granules or if being exposed to spray mist.
- Cartridge-type respirator approved for pesticide vapors unless label specifies another type of respirator.
- Waterproof, unlined gloves. Neoprene gloves are recommended.
- Cloth coveralls/outer clothing changed daily; waterproof items if there is a chance of becoming wet with spray.
- Waterproof boots or foot coverings.
- Do not wear contaminated clothing. Wash protective clothing and equipment with soap and water after each use. Personal clothing must be laundered separately from household articles.
- Clothing contaminated with certain pesticides must be destroyed according to state and local regulations. Read chemical label for specific instructions.
- Wear clothing and equipment appropriate for the job. Avoid loose-fitting clothing.
- Prolonged exposure to loud noise can cause hearing impairment or loss. Wear suitable hearing protection such as earmuffs or earplugs.
- Avoid wearing entertainment headphones while operating machinery. Operating equipment safely requires the full attention of the operator.

Handle Chemicals Properly

Agricultural chemicals can be dangerous. Improper use can seriously injure persons, animals, plants, soil and property.

- Read and follow chemical manufacturer’s instructions.
- Wear protective clothing.
- Handle all chemicals with care.
- Avoid inhaling smoke from any type of chemical fire.
- Store or dispose of unused chemicals as specified by chemical manufacturer.
Avoid High Pressure Fluids
Escaping fluid under pressure can penetrate the skin, causing serious injury.
▲ Avoid the hazard by relieving pressure before disconnecting hydraulic lines.
▲ Use a piece of paper or cardboard, NOT BODY PARTS, to check for suspected leaks.
▲ Wear protective gloves and safety glasses or goggles when working with hydraulic systems.
▲ If an accident occurs, seek immediate medical assistance from a physician familiar with this type of injury.

Use A Safety Chain
▲ Use a safety chain to help control drawn machinery should it separate from tractor draw-bar.
▲ Use a chain with a strength rating equal to or greater than the gross weight of towed machinery.
▲ Attach chain to tractor draw-bar support or other specified anchor location. Allow only enough slack in chain to permit turning.
▲ Replace chain if any links or end fittings are broken, stretched or damaged.
▲ Do not use safety chain for towing.

Use Safety Lights and Devices
Slow-moving tractors and towed implements can create a hazard when driven on public roads. They are difficult to see, especially at night.
▲ Use flashing warning lights and turn signals whenever driving on public roads.
▲ Use lights and devices provided with implement

Keep Riders Off Machinery
Riders obstruct the operator’s view. Riders could be struck by foreign objects or thrown from the machine.
▲ Never allow riders on implement.
▲ Never allow children to operate equipment.
▲ Keep all bystanders away from machine during operation.
**Transport Machinery Safely**

Maximum transport speed for implement is 20 mph (32 kph). Some rough terrains require a slower speed. Sudden braking can cause a towed load to swerve and upset.

- Do not exceed 20 mph. Never travel at a speed which does not allow adequate control of steering and stopping. Reduce speed if towed load is not equipped with brakes.
- Comply with state and local laws.
- Do not tow an implement that, when fully loaded, weighs more than 1.5 times the weight of towing vehicle.
- Carry reflectors or flags to mark implement in case of breakdown on the road.

**Shutdown and Storage**

- Lower implement, put tractor in park, turn off engine, and remove the key.
- This hitch has negative tongue weight when hitched to a three-point drill in the raised position. Always lower drill before unhitching from tractor.
- Secure implement using blocks and supports provided.
- Detach and store implement in an area where children normally do not play.

**Tire Safety**

Tire changing can be dangerous and should be performed by trained personnel using correct tools and equipment.

- When inflating tires, use a clip-on chuck and extension hose long enough for you to stand to one side—not in front of or over tire assembly. Use a safety cage if available.
- When removing and installing wheels, use wheel-handling equipment adequate for weight involved.
Practice Safe Maintenance

▲ Understand procedure before doing work. Use proper tools and equipment. Refer to this manual for additional information.
▲ Work in a clean, dry area.
▲ Lower the implement, put tractor in park, turn off engine, and remove key before performing maintenance.
▲ Make sure all moving parts have stopped and all system pressure is relieved.
▲ Allow implement to cool completely.
▲ Disconnect battery ground cable (--) before servicing or adjusting electrical systems or before welding on implement.
▲ Inspect all parts. Make sure parts are in good condition and installed properly.
▲ Remove buildup of grease, oil or debris.
▲ Remove all tools and unused parts from implement before operation.
▲ Be careful when working around coulter and opener disks. Disks are sharp.

Safety At All Times

Thoroughly read and understand the instructions in this manual before operation. Read all instructions noted on the safety decals.
▲ Be familiar with all implement functions.
▲ Operate machinery from the driver’s seat only.
▲ Do not leave tractor or implement unattended with tractor engine running.
▲ Do not dismount a moving tractor. Dismounting a moving tractor could cause serious injury or death.
▲ Do not stand between the tractor and implement during hitching.
▲ Keep hands, feet and clothing away from power-driven parts.
▲ Wear snug-fitting clothing to avoid entanglement with moving parts.
▲ Watch out for wires, trees, etc., when folding and raising implement. Make sure all persons are clear of working area.
▲ Do not turn tractor too tightly, causing implement to ride up on wheels.
Safety Decals

Safety Reflectors and Decals

Your implement comes equipped with all lights, safety reflectors and decals in place. They were designed to help you safely operate your implement.

▲ Read and follow decal directions.
▲ Keep lights in operating condition.
▲ Keep all safety decals clean and legible.
▲ Replace all damaged or missing decals. Order new decals from your Great Plains dealer. Refer to this section for proper decal placement.
▲ When ordering new parts or components, also request corresponding safety decals.

To install new decals:
1. Clean the area on which the decal is to be placed.
2. Peel backing from decal. Press firmly on surface, being careful not to cause air bubbles under decal.

Slow Moving Vehicle Reflector
(PH-15/PH-20 S/N UU1420+)

818-055C

At rear of main frame; 1 total

Slow Moving Vehicle Reflector
(PFH-15/PFH-20 S/N UU1420+)

818-003C

At rear of left tank; 1 total
Red Reflector (S/N UU1419-)
838-266C
One on each end of toolbar or on markers if installed; 2 total

Red Reflector (S/N UU1420+)
838-266C
One on rear face of mainframe at each end; 2 total

Red Reflector (PH-15/PFH15 S/N UU1420+)
838-266C
One on rear face at end of each light bracket; 2 total

Red Reflector (PH-20/PFH-20 S/N UU1420+)
838-266C
One on rear face at end of each light bracket; 4 total
Amber Reflector (S/N UU1419-)
838-265C
Reflector on both ends of toolbar; 2 total

Amber Reflector (S/N UU1420+)
838-265C
One on front face at ends of outside light brackets, One on each side of tongue; 4 total

Daytime Reflector (S/N UU1420+)
838-267C
One on rear face of mainframe at each end; 2 total

Daytime Reflector (PH-15/PFH-15 S/N UU1420+)
838-267C
One on rear face of each light bracket; 2 total
Daytime Reflector (PH-20/PFH-20 S/N UU1420+)
838-267C

One on rear face of each light bracket; 4 total

Danger: Crushing Two Implements
818-714C

On rear of hitch; 1 total

Danger: Possible Chemical Hazard
818-323C

On optional fertilizer tank
Warning: High Pressure Fluid Hazard
818-339C

Warning: Negative Tongue Weight
818-019C

Warning: Speed
818-188C

On tongue near hitch;
1 total

On top of tongue;
1 total

On front of frame;
1 total
Warning: Pinch/Crush Marker

818-682C

On optional markers on both sides; 4 total

Caution: General Instructions

818-587C

On top of tongue; 1 total

Caution: Tires Not a Step

818-398C

On both sides of hitch frame; 2 total

WARNING: Cancer and Reproductive Harm - www.P65Warnings.ca.gov

Read Owner's Manual before using machine.
Stand clear when folding and unfolding markers.
Stand clear when raising and lowering machine.
Keep all safety shields and devices in place.
Keep hands, feet, and clothing away from moving chains and sprockets.
Never ride on machine.
Always lower or properly support machine BEFORE servicing.
Escaping hydraulic fluid can cause serious injury.
Review safety instructions with all operators annually.

CAUTION

To Avoid Injury from Unsecured Transport Tires:
Never stand on or use transport tires as a step.
Tires not in contact with the ground will rotate easily.

WARNING: Pinch/Crush Marker

To prevent serious injury or death from pinching or crushing:
• Stay away from markers when they are in motion.
• Keep others away.

On both sides of hitch frame; 2 total
Caution: Tire Pressure and Wheel Hardware Torque

838-595C

CAUTION

To Avoid Injury or Machine Damage from Improper Tire Inflation or Torquing of Wheel Bolts:

Maximum inflation pressure of tires is 90 psi.

Torque wheel bolts to 90 - 105 ft-lb.

Two places each wheel strut; 4 total
Introduction

Great Plains welcomes you to its growing family of new product owners. This implement has been designed with care and built by skilled workers using quality materials. Proper setup, maintenance and safe operating practices will help you get years of satisfactory use from the machine.

Description of Unit

The Precision Hitch is a pull-type tillage implement designed to tow a Great Plains three-point drill. No-till coulters are mounted on the hitch. Each coulter is aligned with a drill opener. The coulters till strips for the drill openers. The hitch has two hydraulic circuits: one for raising and lowering the coulters and one for raising and lowering the drill.

The hitch can be outfitted with fertilizer coulters, a drive system, a piston pump and tanks for liquid-fertilizer application. With coulters set at various spacings, the hitch can be used to apply fertilizer in the row below the seedbed at rates from 4 to 80 gallons per acre. Total combined tank capacity is 400 gallons.

Intended Usage

Use this hitch to apply approved liquid fertilizer while seeding production-agriculture crops. Use this hitch in conjunction with Great Plains equipment only. Do not modify the hitch for use with products or attachments other than those specified by Great Plains.

Models Covered

PH-15 and PH-20 (standard model)
PFH-15, and PFH-20 (with fertilizer)

Definitions

The following terms are used throughout this manual.

Right-hand and left-hand as used in this manual are determined by facing the direction the machine will travel while in use unless otherwise stated. An orientation rose in some line art illustrations shows the directions of: Up, Back, Left, Down, Front, Right.

NOTICE

A crucial point of information related to the current topic. Read and follow the directions to remain safe, avoid serious damage to equipment and ensure desired field results.

NOTE:

Useful information related to the preceding topic.

Using This Manual

This manual will familiarize you with safety, assembly, operation, adjustments, troubleshooting and maintenance. Read this manual and follow the recommendations to help ensure safe and efficient operation.

The information in this manual is current at printing. Some parts may change to assure top performance.
Owner Assistance

If you need customer service or repair parts, contact a Great Plains dealer. They have trained personnel, repair parts and equipment specially designed for Great Plains products.

Refer to Figure 2

Your machine’s parts were specially designed and should only be replaced with Great Plains parts. Always use the serial and model number when ordering parts from your Great Plains dealer. The serial-number plate is located on top of the hitch frame as shown in Figure A.

Record your implement model and serial number here for quick reference:

Model Number: ________________________________
Serial Number: ________________________________

Further Assistance

Great Plains Manufacturing, Inc. and your Great Plains dealer want you to be satisfied with your new drill. If for any reason you do not understand any part of this manual or are otherwise dissatisfied, please take the following actions first:

1. Discuss the matter with your dealership service manager. Make sure they are aware of any problems so they can assist you.
2. If you are still unsatisfied, seek out the owner or general manager of the dealership.

If your dealer is unable to resolve the problem or the issue is parts related, please contact:

Great Plains Service Department
1525 E. North St.
P.O. Box 5060
Salina, KS 67402-5060

Or go to www.greatplainsag.com and follow the contact information at the bottom of your screen for our service department.
Preparation and Setup

This section will help you prepare your tractor and hitch for use. Before using the hitch in the field, you must hook the hitch to a suitable tractor and three-point drill, hook the hitch hydraulics to the tractor remotes, and make sure the hitch hydraulics have been bled of air.

Prestart Checklist

1. Read and understand “Important Safety Information” on page 1.
2. Check that all working parts are moving freely, bolts are tight, and cotter pins are spread.
3. Check that all grease fittings are in place and lubricated. Refer to “Lubrication” on page 45.
4. Check that all safety decals and reflectors are correctly located and legible. Replace decals if damaged. See “Safety Decals” on page 6.
5. Inflate tires to pressure recommended and tighten wheel bolts as specified. See “Appendix” on page 53.

Hooking Hitch to Tractor

**DANGER**

Crushing Hazard:
You may be severely injured or killed by being crushed between the tractor and hitch. Do not stand or place any part of your body between hitch and moving tractor. Stop tractor engine and set park brake before installing the hitch pin.

Refer to Figure 3

1. Place hitch weldment (1) over ball swivel (2) on hitch tongue. Hold hitch weldment in place by inserting spacer tube (3) through hitch clevis and ball swivel.
2. Back tractor up to hitch and bolt hitch weldment to tractor drawbar using 1 x 10-inch bolt (4), large flat washer (5), lock washer (6), and nut (7).
3. Use 3/4 x 9-inch bolt (8) to bolt hitch weldment through its slotted hole and onto secondary hole of tractor drawbar. Install a 3/4-inch flat washer (9) next to top slotted hole and fasten with a lock washer (10) and nut (11). Tighten both bolts.
4. Securely attach safety chain to frame of tractor drawbar.

![Figure 3](image-url)
Refer to Figure 4

5. Remove jack from stob on side of hitch tongue and place in transport position on frame brace.

---

Bleeding Air from Hydraulics

**WARNING**

Escaping fluid under pressure can have sufficient force to penetrate the skin. Check all hydraulic lines and hoses before applying pressure. Fluid escaping from a very small hole can be almost invisible. Use paper or cardboard, not body parts, to check for suspected leaks. If injured, seek medical assistance from a doctor that is familiar with this kind of injury. Foreign fluids in the tissue must be surgically removed within a few hours or gangrene will result.

**WARNING**

You could be severely injured or killed by being crushed under the falling implement. Always have transport locks in place and frame sufficiently blocked up when working on implement.

The hydraulics must be bled of air before hitch operation. If the hydraulics are not bled, the cylinders will move with jerky, uneven motions. The hydraulics should be bled during initial hitch setup. If the hydraulics have not be bled, or if you replace a hydraulic component during the life of the drill, follow these procedures.

**Bleeding Tongue Cylinder**

1. Check hydraulic fluid in tractor reservoir and fill to proper level. Add fluid to system as needed. Tongue cylinder capacity is one-half gallon (1.89 liters).
2. Raise and safely support hitch, transport frame and front tongue.
3. Unpin rod end of tongue cylinder. Block, wire or otherwise safely support cylinder so when rod end is fully extended it does not contact anything.
4. Cycle cylinder completely in and out at least three times to purge air from cylinder and hoses.
5. Fully extend cylinder and repin rod end.
6. Recheck tractor reservoir and fill to proper level.
### Bleeding Transport Lift Cylinders

1. Check hydraulic fluid in tractor reservoir and fill to proper level. Add fluid to system as needed. Cylinder capacity is about 2 gallons (7.57 liters).
2. Jack up and support hitch frame.
3. Unpin rod ends of cylinders. Block, wire or otherwise safely support cylinders so when rod ends are fully extended they do not contact anything.
4. Cycle cylinders in and out completely at least three times to purge air from cylinders and hoses.
5. Fully extend cylinders and repin rod ends.
6. Recheck tractor reservoir and fill to proper level.

### Hooking Hitch to Drill

**DANGER**

**Crushing Hazard:**
You may be severely injured or killed by being crushed between the hitch and drill. Do not stand or place any part of your body between the drill and moving hitch. Stop tractor engine and set park brake before installing hitch pins.

**WARNING**

**Negative Tongue Weight Hazard:**
This hitch could have negative tongue weight when hitched to a three-point drill in the raised position. Negative tongue weight will cause the unsecured hitch tongue to raise suddenly and could cause injury or death. Always lower drill before unhooking hitch from tractor.

**Refer to Figure 5**

1. Place hitch extension (1) between top hitch plates on drill. Bolt hitch extension in place as shown using two 1 x 5 1/2-inch bolts (2), lock washers (3) and hex nuts (4).
Refer to Figure 6
2. Move transport-lock handle to field position.

Refer to Figure 7
3. Position quick-hitch handles to locking position as shown. This will allow drill hitch pins to snap into quick-hitch links and secure drill to hitch.
4. Position hitch in front of drill so quick-hitch links on hitch are in line with lower hitch pins on drill. Hydraulically retract transport-lift cylinders to position quick-hitch links slightly lower than drill hitch pins.
5. Back hitch up to drill until hitch pins contact quick hitch. Hydraulically raise hitch just until drill hitch pins are secure inside quick-hitch links. Do not raise drill any higher than necessary.
6. Visually confirm that pins are seated and latches have snapped out over the pins.
Refer to Figure 8

7. Attach slotted link bar (1) to top hitch extension on drill. Use 1 x 3 3/4-inch pin (2) and bushing (3) to pin level-link bar to drill. Secure pin with clip provided (4).

Hooking Up Hydraulic Hoses

![WARNING]

High Pressure Fluid Hazard:
Escaping fluid under pressure can have sufficient force to penetrate the skin. Check all hydraulic lines and hoses before applying pressure. Fluid escaping from a very small hole can be almost invisible. Use paper or cardboard, not body parts, to check for suspected leaks. If injured, seek medical assistance from a doctor that is familiar with this kind of injury. Foreign fluids in the tissue must be surgically removed within a few hours or gangrene will result.

Great Plains hydraulic hoses have color coded handle grips to help you hookup hoses to your tractor outlets. Hoses that go to the same remote valve are marked with the same

<table>
<thead>
<tr>
<th>Color</th>
<th>Hydraulic Function</th>
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<tbody>
<tr>
<td>Red</td>
<td>Tongue Cylinder</td>
</tr>
<tr>
<td>Blue</td>
<td>Transport Lift Cylinders</td>
</tr>
<tr>
<td>Orange</td>
<td>Marker Cylinders</td>
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</table>

To distinguish hoses on the same hydraulic circuit, refer to the symbol molded into the handle grip. Hoses with an extended-cylinder symbol feed cylinder base ends. Hoses with a retracted-cylinder symbol feed cylinder rod ends.

1. Connect hydraulic hoses from tongue cylinder to one set of tractor outlets.
2. Connect hoses from transport-lift cylinders to another set of tractor outlets.
3. Connect hoses from optional markers to a third set of tractor outlets.
For Older Models

Refer to Figure 10

To distinguish hoses on the same hydraulic circuit, refer to plastic hose holder. Hose under extend-cylinder symbol feeds cylinder base ends. Hose under retracted-cylinder symbol feeds cylinder rod ends.

Figure 10
Hydraulic Hose Color Ties
Operating Instructions

This section covers general operating procedures. Experience, machine familiarity and the following information will lead to efficient operation and good working habits. Always operate farm machinery with safety in mind.

Prestart Checklist
1. Carefully read “Important Safety Information” on page 1.
2. Lubricate implement as indicated under “Lubrication” on page 45.
3. Check all tires for proper inflation.
4. Check all bolts, pins and fasteners. Torque as specified on “Torque Values Chart” on page 53.
5. Check implement for worn or damaged parts. Repair or replace before going to the field.
6. Check hydraulic hoses, fittings and cylinders for leaks. Repair or replace before going to the field.

Field Operation

**DANGER**

**Crushing Hazard:**
You may be severely injured or killed by being crushed between the tractor and hitch. Do not stand or place any part of your body between hitch and moving tractor. Stop tractor engine and set park brake before installing the hitch pin.

**WARNING**

**High Pressure Fluid Hazard:**
Escaping fluid under pressure can have sufficient force to penetrate the skin. Check all hydraulic lines and hoses before applying pressure. Fluid escaping from a very small hole can be almost invisible. Use paper or cardboard, not body parts, to check for suspected leaks. If injured, seek medical assistance from a doctor that is familiar with this kind of injury. Foreign fluids in the tissue must be surgically removed within a few hours or gangrene will result.

1. Hook hitch to a suitable tractor and drill. Refer to “Hooking Hitch to Tractor” on page 15 and “Hooking Hitch to Drill” on page 17.

Refer to Figure 11

2. Move transport-lock handle to field position.

---

**CAUTION**

**Spill hazard/Tank damage risk:**
Periodically check the tension of the straps for the fertilizer tank. Strap tension will change as outside air temperature changes. Adjust tension as necessary to prevent personal injury or damage to the fertilizer tank.

---

Figure 11
Transport-Lock Handle, Field Position
Refer to Figure 12
3. Remove cylinder lock channel from tongue cylinder.

Refer to Figure 13
Store channel on support gusset.

4. Set and calibrate drill seeding rate. Refer to drill operator's manual.

5. Adjust coulters for necessary down pressure and desired depth. Refer to "Coulter Depth" on page 29 and "Coulter Down Pressure" on page 30, for adjustment instructions.

6. Adjust drill seeding depth. Refer to drill manual.

7. Level hitch and drill. Refer to "Leveling Adjustment" on page 32.

8. Pull forward, lower coulters and drill, and begin seeding.

9. After seeding for a short distance, stop with the drill and hitch in the ground. Inspect the drill for proper operation including the following:
   - Confirm that the automatic pivot locks have raised, so the hitch is free to articulate and track properly on curves. (See "Pivot Locks" on page 26, for more information.)
   - Confirm that seed is being metered.
   - Check seed depth.

10. Always lift drill out of ground when turning at row ends and for other short turns. Seeding and fertilizer application will stop automatically as you raise the coulters and drill for field turns. The hitch’s pivot locks will also engage while turning.
Fertilizer Application Option

⚠️ DANGER

Some chemicals will cause serious burns, lung damage and death. Avoid contact with skin or eyes. Wear proper protective equipment as required by chemical manufacturer. Avoid prolonged breathing of chemical fumes. Wear respirator as required by chemical manufacturer. Seek medical assistance immediately if accident occurs. Know what to do in case of an accident.

The fertilizer-application system uses a piston pump. The pump is ground driven. The pump moves fertilizer into a plumbing manifold mounted along the coulter toolbar.

An orifice is installed under the quick cap on each manifold outlet. The orifice creates a small amount of back pressure in the manifold and prevents the outlets nearest the pump from getting too much of the total flow.

Since the pump is a positive displacement pump, the overall application rate is determined by the pump setting (stroke) and the size of the pump driver sprocket. The size of the orifice does not affect the application rate.

To operate the liquid-fertilizer system, follow these steps:

1. Choose a sprocket range and pump setting for your desired application rate. Refer to “Fertilizer Application Rates” on page 34.
2. Adjust driver sprocket and pump setting as necessary. Refer to “Adjusting Fertilizer Application Rate” on page 33.
3. Choose proper orifice to match your application rate. Install proper orifice plates. Refer to “Orifice Plates” on page 35.
4. Adjust fertilizer tines to correct position. Refer to “Adjusting Fertilizer Tines” on page 36.
5. Set manifold relief valve. Refer to “Setting Relief Valve” on page 36.
6. Fill fertilizer tanks.
   a. Connect nurse-tank hose to quick-fill coupler shown in Figure 14. Lock hose in place with cam-lock levers.
b. Close piston-pump valve shown in Figure 15.

c. Open valves at each tank and at quick-fill coupler.

d. Fill tanks, then close valve at quick-fill coupler, and disconnect the nurse tank hose.

Always fill fertilizer tanks to equal levels. If one tank fills more quickly, shut that tank valve off to raise the level in the other tank.
Refer to Figure 17

7. Open piston-pump valve.

Refer to Figure 18

8. While operating in the field, watch manifold pressure gauge mounted above piston pump.

By watching the manifold pressure when operating at field speeds, you can confirm that you have the correct orifice plates needed to keep the manifold pressure between 5 psi and 85 psi. If the gauge reads below 5 psi or above 85 psi, use different orifice plates.

If the gauge reading increases slowly over time, check for plugging at the orifice plate(s) under the quick cap(s) or at the nozzle behind the coulter blade. If the gauge reading drops suddenly, check for empty tanks, or a disconnected pump supply hose.

**NOTE:**
The tank shutoff valves supplied from the factory are 3-way ball valves with the ports facing the rear of the machine plugged. With this port plugged use the valves as standard on/off valves. The 3-way valves have been provided to make a conversion to a dual product system easier. By removing the plugs on the rear port of the 3-way valves, and by adding some additional plumbing and a second pump, the unit can be used in these scenarios:

- Both tanks hold product 1. (example starter). Both tanks are routed to the starter pump by turning the 3-way valves forward.
- One tank holds product 1, the other tank product 2. Fill the tanks one at a time through the same quick fill line. Supply two different pumps the two different products by turning on valve handle forward, and the other handle rearwards.
- Both tanks hold product 2. Both tanks are routed to the second pump by turning both handles rearwards. Always turn the long part of the handle to point the direction you want the product to flow. Setting the handle at 90 degrees to the side ports shuts off the flow to all ports.
Marker Option
Optional marker attachments are available from your Great Plains dealer. Before operating markers, make sure hydraulics have been bled properly.

The dual markers are equipped with a sequence valve and are powered off one hydraulic circuit. Starting with both markers folded, the folding sequence is:

1. Activate lever – Right unfolds; left stays folded.
2. Reverse lever – Right folds up; left stays folded.
3. Activate lever – Left unfolds; right stays folded.
4. Reverse lever – Left folds up; right stays folded.
5. Sequence repeats.

You can adjust marker folding speed. Refer to “Marker Adjustments” on page 39, and adjust folding speed to a safe rate. Folding markers at high speed can damage markers.

Pivot Locks
Pivot-locks are located in front of the transport frame. The tubes provide stability during hitch transport. When hitch is raised, pivot-lock tubes rotate down to restrict hitch pivoting. When hitch is lowered, pivot-lock tubes rotate up and allow hitch and frame to pivot freely in the field.

In most field conditions, allow pivot-lock tubes to raise and lower automatically. Store pin shown in Figure 19 in its storage hole (1).

When planting on steep slopes or when backing hitch during hookup, up may need to lock the tubes for increased stability. To lock tubes, insert pin over lowered tubes (2) as shown in Figure 19.

You can adjust spring tension on pivot-lock tubes. Refer to “Pivot Lock Adjustment” on page 40.
Transporting

⚠️ WARNING

Towing the implement at high speeds or with a vehicle that is not heavy enough can lead to loss of vehicle control. Loss of vehicle control can lead to serious road accidents, injury and death. To reduce the hazard:

- Do not exceed 20 mph (32 kph).
- Secure transport locks and channel as explained below.
- Do not tow an implement that, when fully loaded, weighs more than 1.5 times the weight of the towing vehicle.
- Unload all liquid fertilizer from implement tanks before transporting.

⚠️ CAUTION

Spill hazard/Tank damage risk:
Periodically check the tension of the straps for the fertilizer tank. Strap tension will change as outside air temperature changes. Adjust tension as necessary to prevent personal injury or damage to the fertilizer tank.

1. Check that hitch is hooked securely to a sufficient tractor. Refer to “Hooking Hitch to Tractor” on page 15.
2. Unload liquid fertilizer from hitch tanks.
3. Unload drill seed box before transporting if at all possible. The implement can be transported with a full box of grain, but the added weight will increase stopping distance and decrease maneuverability.
4. Check that tires are properly inflated.
5. Hydraulically raise coulters and lift drill.

Refer to Figure 20

6. Move transport-lock handle to road position.
7. Check that the transport locks are engaged.

Figure 20
Transport-Lock Handle in Road Position
Refer to Figure 21

8. Pin cylinder-lock channel over extended rod on tongue cylinder.
9. Know implement dimensions in transport position. Choose a route that provides adequate clearance from all obstructions. Refer to “Specifications and Capacities” on page 51, for dimensions.
10. Comply with all laws when traveling on public roads.

Parking

⚠️ WARNING

Negative Tongue Weight Hazard:
This hitch could have negative tongue weight when hitched to a three-point drill in the raised position. Negative tongue weight will cause the unsecured hitch tongue to raise suddenly and could cause injury or death. Always lower drill before unhooking hitch from tractor.

Perform the following steps when parking implement. Refer to “Storage” on page 44, for information on long-term storage.

1. Park implement on a firm, level area. Lower coulters and drill to ground.
2. Block tires securely to prevent rolling.
3. Release pressure on hydraulic system, then disconnect hydraulic lines. Position hoses on hitch tongue so hose ends do not rest on ground.
4. Move jack from transport position and place it on stob on side of hitch tongue.
5. Extend jack until all weight is off tractor drawbar. Remove 1 x 10-inch bolt, washer and nut.
Adjustments

Coulter Depth

A no-till coulter is mounted on the hitch directly ahead of each opener on the drill. The coulters cut through heavy trash and make a groove in the soil for the openers.

The hitch is designed to allow coulters to penetrate approximately two inches (5 centimeters) into the soil when the tongue is level. Depth can be adjusted hydraulically for all coulters or manually for individual coulters. Adjust coulters 1/2 to 1 inch deeper than the drill openers.

Hydraulic Control

Refer to Figure 23

Make the following adjustment when drilling in level ground with the seed box half full. Extend or retract tongue cylinder so that coulters are at desired depth. Note setting on cylinder gauge so that you can return to the same depth.

1. Extend or retract tongue cylinder so that coulters are at desired depth. Note setting on cylinder gauge so that you can return to the same depth.

\[\text{NOTE:}\]
Use cylinder gauge as a reference only. Gauge does not measure actual coulter depth.

Coulter Mounting Height

You can change the depth of individual coulters by adjusting coulter-mounting height. If you adjust coulter height, be sure to bolt coulters vertically straight and spaced correctly. To raise or lower an individual coulter:

1. Loosen mounting clamps and adjust coulter to desired height. Do not lower coulter spring bar below top u-bolts on coulter clamp.

Refer to Figure 24

2. To retighten clamps. Snug hex-head clamp bolts (1) just until u-bolts are tight on each side of spring bar.
3. Tighten nuts (2) on u-bolts.
4. Finish tightening hex-head clamp bolts.

\[\text{NOTE:}\]
Even when coulter is held securely, there may be a gap between clamp halves.
Coulter Down Pressure

The amount of coulter down pressure needed to cut a soil groove varies with soil conditions. Hard soil or heavy crop residue may cause shallow penetration. If coulter penetration is different than desired, add weight or shorten coulter springs to improve coulter penetration.

Added Weight

Refer to Figure 25

In hard soil conditions where coulter penetration is limited, you can add suitcase weights to brackets on hitch frame. Adding weight on hitch frame provides best weight distribution for no-till drilling. You can add up to 2,000 pounds of additional weight. Place an equal amount of weight on each weight bracket.

NOTE:
Models PFH-15 and PFH-20 do not have weight brackets. To increase weight on models PFH-15 and PFH-20, do not run fertilizer tanks empty. Instead, use weight of liquid in tanks to improve coulter penetration.

Coulter Springs

Refer to Figure 26

Coulter spring length is preset at the factory to 10 inches, giving coulters an initial operating force of 400 pounds (181 kg). This setting is adequate for many difficult no-till conditions. For lighter no-till conditions where rocks or other obstructions are a problem, you can reduce spring load to give coulters better impact protection. Refer to the following chart when adjusting coulter spring length.

NOTE:
Do not reset coulter spring length shorter than 9 3/4 inches (24.77 centimeters). Shortening springs more than 9 3/4 inches (24.77 centimeters) may contribute to premature failure of parts and warranty will be voided.

<table>
<thead>
<tr>
<th>Spring Length</th>
<th>Preload</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 1/2 in (26.67 cm)</td>
<td>175 lbs (79 kg)</td>
</tr>
<tr>
<td>10 1/4 in (26.03 cm)</td>
<td>300 lbs (136 kg)</td>
</tr>
<tr>
<td>10 in (25.40 cm)</td>
<td>400 lbs (181 kg)</td>
</tr>
<tr>
<td>9 3/4 in (24.77 cm)</td>
<td>525 lbs (238 kg)</td>
</tr>
</tbody>
</table>
Lock Plate

Set lock plate to match your field conditions. The lock plate is at the top drill link.

No-Till or Hard, Dry Soil Conditions

Refer to Figure 27

For maximum opener penetration, operate drill and hitch in rigid position. The rigid position is the most common position for no-till seeding and is effective for a wide range of field conditions. Lock plate down over top link pin.

Minimum Till, Average Soil with Hills and Terraces

Refer to Figure 28

For softer soils that have been tilled lightly and for drilling over hills, contours, ditches or terraces, operate drill in limited-float position. Leave lock plate unlocked and adjust level link so top link pin is at back of slot. (Refer to “Leveling Adjustment” on page 32.) The limited-float position allows hitch and drill to flex when traveling over contours but transfers enough weight to drill for opener penetration in softer soils.

Conventional Till, Very Soft Soils (00 Series Openers Only)

Refer to Figure 29

For maximum flotation over hills and contours in soft soils, operate drill and hitch in maximum-float position. Leave lock plate unlocked and adjust level link so top link pin is in center of slot. In maximum-float position, drill tips forward and back independent of hitch.
Leveling Adjustment

Refer to Figure 30

After setting lock plate to position that matches your field conditions, adjust top link so drill runs level in the field.

1. With drill box half-full of seed, lower drill and coulters into field position in the field.
2. Observe drill and hitch from the side. The top of drill box (1) should be parallel with the ground.
3. If necessary, adjust level link. Raise drill and hitch, unlock lock plate and unpin level link (2) from hitch. Loosen jam nut (3) and turn eye bolt to shorten or lengthen link as necessary.
4. Repin link, lower drill and coulters and recheck top of drill box. When drill box is parallel with ground, tighten jam nuts.

Figure 30
Leveling Adjustment
Fertilizer Application Option

The fertilizer-application system uses a piston pump. The pump is ground driven. The pump moves fertilizer into a plumbing manifold mounted along the coulter toolbar.

An orifice is installed under the quick cap on each manifold outlet. The orifice creates a small amount of back pressure in the manifold and prevents the outlets nearest the pump from getting too much of the total flow.

**NOTE:**
Remember, application rates are determined by pump setting and size of pump driver sprocket. Orifice size does not affect the application rate.

The following instructions and rate chart apply to the John Blue model LM-2455 piston pump sold as an option with the PFH-15 and PFH-20.

**Adjusting Fertilizer Application Rate**

Refer to Figure 31

1. Refer to rate chart. Find your desired application rate and note sprocket range (high or low) and pump setting required for your desired application rate.

2. Set sprocket range. Check the number of teeth on the driver sprocket.
   - For low range, use the 23-tooth sprocket
   - For high range, use the 47-tooth sprocket

To change sprockets, loosen the twin idler sprockets and remove chain. Pull quick pins off end of shaft and end of sprocket-storage post. Swap the sprockets and reinstall quick pins and chain. Route the chain as shown.

Refer to Figure 32

3. Set pump. Loosen scale-setting nut (1) on side of pump-calibration dial. Use special wrench (2) from John Blue to rotate notched disk until pointer is at desired setting. Tighten scale-setting nut, being careful not to over tighten nut.

**NOTE:**
The adjustment wrench can be stored in a slot (3) provided in the pump mount bracket.
Fertilizer Application Rates

<table>
<thead>
<tr>
<th>Pump Setting</th>
<th>Application Rates, Gallons per Acre</th>
<th>15-Foot Hitches</th>
<th>20-Foot Hitches</th>
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<tbody>
<tr>
<td>Low Range</td>
<td>High Range</td>
<td>Low Range</td>
<td>High Range</td>
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<tr>
<td>(23 Tooth)</td>
<td>(47 Tooth)</td>
<td>(23 Tooth)</td>
<td>(47 Tooth)</td>
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<tr>
<td>100</td>
<td>51</td>
<td>38</td>
<td>79</td>
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</tbody>
</table>

Strainer

A Banjo brand strainer is supplied with the fertilizer pump option and is to be plumbed before the John Blue pump. The standard 80 mesh screen should be suitable for most applications. Other screen sizes are available from Banjo Corporation. If changing screen sizes, keep in mind the following.

- A smaller mesh (100) will keep the very small manifold orifice plates from plugging so often. However, the screen will have to be cleaned more often.
- A larger mesh (50) or (30) will pass more material but should only be considered when using large manifold orifice plates.
- A plugged or partially plugged screen will starve the pump and will result in a reduced application rate.
- John Blue recommends using a 30 mesh screen or tighter to protect their pump.
- Mesh sizes: (Smallest) 100, 80, 50, 30 (Largest)
Orifice Plates

In general, the orifice needs to be small enough to create at least 5 psi of pressure in the manifold but large enough to prevent the manifold pressure from exceeding 85 psi. To reduce orifice plugging and pump wear, use the largest orifice practical for your fertilizer application rate.

The PFH-15 and PFH-20 have 0.048-inch orifices as standard equipment. You can order the other Tee-Jet orifices listed on the following chart from your Great Plains dealer. Many other orifice sizes are available through Tee-Jet.

To choose and install the proper orifice plate:
1. Find your hitch width and row spacing on the chart.
2. Select the largest orifice that includes your application rate.

*Orifice-48 is provided as standard equipment with manifold. Orifices of other sizes must be ordered. Contact your Great Plains dealer.

TIP: When using very low application rates, you may find that the small orifices plug too often. Consider adding water to your fertilizer and increasing the rate. This will allow you to switch to a larger orifice.

Example: 10 GPA original rate. (1) Mix 200 gallons of fertilizer with 200 gallons of water. Your product is now at half strength. (2) Double your application rate to 20 GPA. Your ACTUAL fertilizer rate is still 10 GPA.
Setting Relief Valve

Refer to Figure 34

A relief valve is mounted directly above the pump to protect the manifold and pump from excessive pressure. Any product that dumps over the relief valve will discharge from the dump line (1).

To set relief valve:
1. Unlock plastic jam nut (2) from relief-valve knob.
2. Unscrew knob (3) counterclockwise until it loses contact with internal spring.
3. Screw knob clockwise two turns. Start at this setting.
4. Observe manifold gauge and watch for relief-valve discharge while operating in the field.
   • If valve is dumping product and gauge reads under 85 psi, stop tractor and turn knob clockwise 1/4 turn. Continue operating at normal field speed. Repeat this step as needed until no product is discharged from relief valve.
   • If the pressure gauge reads above 85 psi, change to a larger orifice, following the guidelines in the orifice selection table. Go to step 2 and repeat steps.

Adjusting Fertilizer Tines

Your main objective when adjusting the fertilizer tine is to position the nozzle so it sprays into the void created by the slicing action of the coulter blade. This allows the nozzle to inject fertilizer to the bottom of the trench.

Refer to Figure 35

When positioning tines:
- Set fertilizer tines so bottom of tines are about 1 to 1 1/2 inch below the soil surface. You can set the tines deeper, but you risk causing excessive wear and plugging.
- Set tines about 1 to 1 1/2 inch behind the coulter blade in a vertical or slightly back swept position.
- Set tines in line with the coulter blade.

The fertilizer coil tines are adjustable in three ways: side to side, front to back and up and down. Refer to the following instructions to adjust the fertilizer coil tines properly.
Side to Side Adjustment Fertilizer Tine

The fertilizer tine must be straight with the coulter blade and centered behind the coulter blade. To alter the side to side rotation of the tine:

**Refer to Figure 36**

1. Remove 1/2-inch, hex-flange nut and flat washer (1) holding tine (2) on back arm (3).
2. Center tine behind coulter blade by adding or removing rectangular spacer washers (4) that fit between back arm and fertilizer-tine clip (5). Store unused spacer washers on opposite side of back arm.
3. If a finer adjustment is needed to center tine behind coulter blade, place a 1/2-inch flat washer (6) between front arm and back arm to shim them apart. Store unused washers on outside of back arm under 1/2-inch flange nuts (7).
4. When tine is centered behind coulter blade, adjust tine so it is aligned vertically with the coulter blade. If necessary, remove hex-flange nuts (7) holding back arm to front arm. To rotate bottom of tine counterclockwise, place one 1/2-inch flat washer between front arm and back arm on lower hex flange bolt (9). Retighten hex flange nuts and store extra washers behind hex-flange nuts.

**Front to Back Adjustment**

1. Loosen hex flange nuts (7) holding back arm to front arm.
2. Rotate back arm assembly until tine is in a vertical or slightly swept back position and between 1 to 1 1/2 inch behind coulter.
3. Retighten hex flange nuts.

**Up and Down Adjustment**

1. To adjust tine depth, remove 1/2-inch hex flange nut and flat washer (1) holding coil tine (2) to back arm (3).
2. Position tine to desired height by placing hooked end of the coil tine (10) in one of the five holes in back plate.
3. Secure tine to back arm by reassembling 1/2 x 4 1/2-inch bolt (11) through round spacer tube (12), clip, rectangular spacers and back arm. Secure with a flat washer and hex flange nut.

![Figure 36 Tine Adjustment](image-url)
Liquid Fertilizer Arm
Up and down Adjustment

*Refer to Figure 37*

To adjust the height of the Liquid Fertilizer Arm (1) loosen the nuts (3) on the 1/2 x 1 3/4-inch bolts (2). Slide arm (1) up or down to the desired height and retighten nuts (3) and bolts (2).

Figure 37
Liquid Fertilizer Arm Adjustment
Marker Adjustments

Folding Speed

*Refer to Figure 38*

Adjust folding speed with hex adjustment screws on the sequence-valve body. There is one adjustment screw for raising speed (1) and one for lowering speed (2). Identify adjustment screws by markings stamped in valve body.

With tractor idling at a normal operating speed, adjust marker folding to a safe speed. Turn adjustment screws clockwise to decrease folding speed and counterclockwise to increase folding speed. Excessive folding speed could damage markers and void the warranty.

After adjusting folding speed, tighten jam nuts on hex adjustment screws to hold settings.

![Figure 38](14048)

Speed Adjustment, Sequence Valve

Marker Width

*Refer to Figure 39*

To adjust marker width, loosen marker tube u-bolt (1) and slide marker tube in or out as necessary. After adjusting, retighten u-bolt.

![Figure 39](15835)

Marker Width Adjustment
Disk Adjustments
The mark left by the marker disk may be changed by two methods.

Refer to Figure 40
1. Disk Angle:
   To change the angle of cut, loosen bolts (1), rotate spindle assembly (4) and retighten bolts.
2. Direction of Cut:
   To change the direction the disk cuts:
   a. Remove four lug bolts on disk hub and reverse depth band (2) and blade (3). Reinstall lug bolts.
   b. Remove bolts (1) and spindle assembly (4). Reinstall spindle assembly so it is on top of marker tube. Tighten all bolts.

Pivot Lock Adjustment

Refer to Figure 41
To adjust the gap on pivot-locks, loosen jam nut (1) and screw bolt (2) in or out to desired setting, then retighten jam nut. When pivot frame is 90 degrees to tongue, bolt head should be about 1/16 inch (0.16 centimeter) away from hitch frame.

If the pivot locks do not automatically unlock in field position, or lock in field position, check for binding in the locks, and confirm that both sides have the 1/16 inch gap discussed above.
Leaf Spring Adjustment

Refer to Figure 42

A leaf spring is located just ahead of the vertical pivot. The spring is designed to provide just enough force to keep the hitch square and stable for turning at field ends and to add stability for drilling in rough field conditions. Proper leaf-spring adjustment is important for smooth implement operation.

Square tongue with transport frame and adjust 3/8-inch u-bolts (1) on each side until leaf-spring rollers (2) just make contact with roller pads (3) on transport frame. Make sure both right and left sides are adjusted properly.

Figure 42
Leaf Spring Adjustment
## Troubleshooting

<table>
<thead>
<tr>
<th>Problem</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fertilizer coulter plugging</strong></td>
<td>Fertilizer tine is running too deeply or is not aligned properly. Refer to “Adjusting Fertilizer Tines” on page 36.</td>
</tr>
<tr>
<td><strong>Fertilizer output rate too low</strong></td>
<td>Check air pressure in fertilizer drive wheel.</td>
</tr>
<tr>
<td></td>
<td>Check for plugging in fertilizer hoses, plumbing and pump strainer.</td>
</tr>
<tr>
<td></td>
<td>Check that you have installed the correct driver sprocket and set the pump to the proper setting. Refer to “Adjusting Fertilizer Application Rate” on page 33.</td>
</tr>
<tr>
<td></td>
<td>Consider soil conditions. Drive-wheel slippage can alter application rates.</td>
</tr>
<tr>
<td><strong>Coulters not going deep enough</strong></td>
<td>Retract tongue cylinder. Refer to “Hydraulic Control” on page 29.</td>
</tr>
<tr>
<td></td>
<td>Too much weight is being used by openers. Set drill openers to lightest spring setting. Refer to your drill operator’s manual.</td>
</tr>
<tr>
<td></td>
<td>On models PH-15 and PH-20, add suitcase weights to hitch weight brackets. Refer to “Added Weight” on page 30. NOTE: Do not add more than 2000 pounds.</td>
</tr>
<tr>
<td></td>
<td>On models PFH-15 and PFH-20, do not run fertilizer tanks empty. Use weight of liquid fertilizer to improve coulter penetration.</td>
</tr>
<tr>
<td></td>
<td>Shorten springs on individual coulters. Refer to “Coulter Springs” on page 30.</td>
</tr>
<tr>
<td></td>
<td>Lower individual coulters to compensate for tire tracks. Refer to “Coulter Mounting Height” on page 29.</td>
</tr>
<tr>
<td><strong>Drill not tracking behind coulters.</strong></td>
<td>Check that coulters and drill openers are same distance from center of implement.</td>
</tr>
<tr>
<td></td>
<td>Check that pivot lock tubes are rotating up while drilling. Make sure that pivot lock tubes are not locked down. Refer to “Pivot Locks” on page 26.</td>
</tr>
<tr>
<td></td>
<td>Check for proper leaf-spring adjustment. “Leaf Spring Adjustment” on page 41.</td>
</tr>
<tr>
<td><strong>Openers plugging in no-till conditions.</strong></td>
<td>Drill at a slight angle to the rows.</td>
</tr>
<tr>
<td><strong>Drill is seeding too deeply.</strong></td>
<td>Adjust level link so that drill will not tip back in seeding position. Refer to “Lock Plate” on page 31.</td>
</tr>
<tr>
<td></td>
<td>Move press-wheel adjustment on openers to a shallower depth. Refer to your drill operator’ manual.</td>
</tr>
<tr>
<td><strong>Transport lift cylinders losing lift height</strong></td>
<td>Inspect for wear on clevis pin and bushings on rod end of cylinder.</td>
</tr>
<tr>
<td><strong>Reading on manifold pressure gauge above 85 psi or below 5 psi.</strong></td>
<td>Use different orifice plates. Refer to “Orifice Plates” on page 35.</td>
</tr>
<tr>
<td><strong>Reading on manifold pressure gauge increases slowly over time.</strong></td>
<td>Check for plugging at orifice plate under quick cap or at nozzle behind coulter blade.</td>
</tr>
<tr>
<td><strong>Reading on manifold pressure gauge drops suddenly.</strong></td>
<td>Check for a disconnected hose in the manifold supply plumbing.</td>
</tr>
<tr>
<td></td>
<td>Check if tanks are empty.</td>
</tr>
</tbody>
</table>
Maintenance and Lubrication

Maintenance

**WARNING**

**Crushing Hazard:**
You could be severely injured or killed by being crushed by the falling implement. Always have transport locks in place and frame sufficiently blocked up when working on implement.

**WARNING**

**Negative Tongue Weight Hazard:**
This hitch could have negative tongue weight when hitched to a three-point drill in the raised position. Negative tongue weight will cause the unsecured hitch tongue to raise suddenly and could cause injury or death. Always lower drill before unhooking hitch from tractor.

**WARNING**

**High Pressure Fluid Hazard:**
Escaping fluid under pressure can have sufficient pressure to penetrate the skin. Check all hydraulic lines and fittings before applying pressure. Fluid escaping from a very small hole can be almost invisible. Use paper or cardboard, not body parts, and wear heavy gloves to check for suspected leaks. If injured, seek medical assistance from a doctor that is familiar with this type of injury. Foreign fluids in the tissue must be surgically removed within a few hours or gangrene will result.

**WARNING**

**Sharp Disk Hazard:**
Coulter and opener disks may be sharp enough to cut flesh. Be careful when working around coulter and opener disks.

Proper servicing and maintenance is the key to long implement life. With careful and systematic inspection, you can avoid costly maintenance, downtime and repair.

Always turn off and remove tractor key before making any adjustments or performing any maintenance.

**CAUTION**

**Spill hazard/Tank damage risk:**
Periodically check the tension of the straps for the fertilizer tank. Strap tension will change as outside air temperature changes. Adjust tension as necessary to prevent personal injury or damage to the fertilizer tank.

1. After using implement for several hours, check all bolts to be sure they are tight. Check all valves, fittings, hose clamps and plugs to be sure they are tight.
2. Inflate tires as necessary.

3. Lubricate hitch as listed under “Lubrication” on page 45.
4. Replace any worn, damaged or illegible safety decals. Obtain new decals from your Great Plains dealer. Refer to “Safety Decals” on page 6, for decal placement.
5. Check hitch safety chain. Make sure chain is properly attached to hitch. Inspect chain for wear or other damage. Replace immediately if needed.
6. Check fertilizer drive chains for wear. Replace if necessary. Adjust idlers to remove excess slack from chains.

**Marker Maintenance**
The marker arm is attached to marker body with a 3/8-inch, grade 2, shear bolt. If shear bolt breaks, replace it with a grade 2 bolt.

If grease-seal cap for marker disk bearings is damaged or missing, disassemble and clean hub. Repack with grease and install a new seal or grease cap.

**Fertilizer Cleanout**

**DANGER**

**Chemical Hazard:**
Some chemicals will cause serious burns, lung damage and death. Avoid contact with skin or eyes. Wear proper protective equipment as required by chemical manufacturer. Avoid prolonged breathing of chemical fumes. Wear respirator as required by chemical manufacturer. Seek medical assistance immediately if an accident occurs. Know what to do in case of an accident.

Proper and regular cleanout is the best way to prolong piston-pump life. Do not allow air to enter the pump, even for short periods of time. Air in the pump will cause rapid and severe corrosion.

**After each day’s use:**

1. Flush tanks, nozzles, hoses and pump with clean water. Do not allow air into the pump.
2. Do not drain the pump. Leave fresh water in pump overnight.
3. Wash any components that may have been exposed to fertilizer.

**For two- to three-week storage:**

After flushing fertilizer system with water, immediately fill all pump passages with motor oil. Replace pump manifold and plug pump inlet and outlet with a stopper or oily rag.
Storage

**WARNING**

*Negative Tongue Weight Hazard:*
This hitch could have negative tongue weight when hitched to a three-point drill in the raised position. Negative tongue weight will cause the unsecured hitch tongue to raise suddenly and could cause injury or death. Always lower drill before unhooking hitch from tractor.

Store the hitch where children do not play. If possible, store the hitch inside for longer life.
1. Clean hitch as necessary.
2. Lubricate all fittings and chains as indicated under “Lubrication” on page 45.
3. Lower coulters onto a hard surface or board. Apply a light coat of oil to exposed cylinder rods.

**Pump and Fertilizer Tank**

To prepare for long-term storage:
1. Flush tanks, nozzles, hoses and pump thoroughly with fresh, warm water. Circulate water until all corrosive salts in pump are dissolved.
2. Set pump dial to 10. Draw a mixture of half diesel fuel and half #10 oil into pump. Continue drawing fuel and oil mixture into pump until discharge is clean.
3. Plug pump inlet and outlet.
4. Wash any components that may have been exposed to fertilizer.
5. Drain filter, fittings and ball valves. Any water left in the system may freeze and damage these parts.
Lubrication

**Tongue to Hitch Frame Pivot**

- 1 grease fitting
- Type of Lubrication: Grease
- Quantity: Until grease emerges from pivot

**Level Link Pivot**

- 1 grease fitting
- Type of Lubrication: Grease
- Quantity: Until grease emerges from pivot

**Coulter Swing Arms**

- 1 grease fitting per coulter
- Type of Lubrication: Grease
- Quantity: Until grease emerges from pivot

**Coulter Hubs**

- 1 grease fitting per coulter
- Type of Lubrication: Grease
- Quantity: Pump grease into bearings until resistance is felt, being careful not to pressurize seal or blow out cap
Marker Pivot Points

3 grease fittings per marker
Type of Lubrication: Grease
Quantity: Until grease emerges from pivot points

Marker Disk Bearings

Type of Lubrication: Grease
Quantity: Repack bearings

Rockshaft Bearings

2 grease fittings total, one on each side of hitch
Type of Lubrication: Grease
Quantity: Until grease emerges from pivot

Vertical Pivot

2 grease fittings total, on top and on bottom bushing
Type of Lubrication: Grease
Quantity: Until grease emerges from pivot
Rockshaft to Hitch Frame Pivot

3 grease fittings
Type of Lubrication: Grease
Quantity: Until grease emerges from pivot

Wheel Bearings

Type of Lubrication: Grease
Quantity: Repack bearings

Fertilizer Option

Coulter Command/Fertilizer Drive Wheel

1 grease fitting on each side of arm
Type of Lubrication: Grease
Quantity: Until grease emerges

Piston Pump Drive Chain

Type of Lubrication: Chain Lube
Quantity: Coat thoroughly
Piston Pump Crankcase

Seasonal

Oil must be visible at oil check
Type of Lubrication: 90-weight, EP gear oil
Quantity: Fill crankcase

Piston Pump Grease Fittings

2 grease fittings
Type of Lubrication: Grease
Quantity: Fill until grease seeps from bottom drain hole
Options

Liquid Fertilizer Options
Tanks, drive wheel, piston pump, manifold and fertilizer tines are available. With these options, you can create a customized application system for your fertilizer-application needs.

Drive Wheel
The drive wheel mounts on the coulter toolbar and can power any liquid pump with a sprocket input.

<table>
<thead>
<tr>
<th>Package</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drive Wheel Assembly</td>
<td>148-339K</td>
</tr>
</tbody>
</table>

Tanks
Models PH-15 and PH-20 can be outfitted with liquid-fertilizer tanks. Each durable, non-corrodible tank holds 200 gallons.

<table>
<thead>
<tr>
<th>Package</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanks and Primary Plumbing</td>
<td>148-367L</td>
</tr>
</tbody>
</table>

Piston Pump
The pump package contains a John Blue piston pump, all mounting hardware and pump plumbing. The pump is a ground-driven, positive-displacement piston pump manufactured by John Blue Company. The package also comes with an inlet filter to reduce plugging.

<table>
<thead>
<tr>
<th>Package</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piston Pump, Mount and Plumbing</td>
<td>148-366L</td>
</tr>
</tbody>
</table>

Manifold Bundles
The manifold bundles contain the manifold, wet boom, nozzle bodies and plumbing needed to connect the pump to the fertilizer tines. The packages are designed for fertilizer application on every row. Manifold outlets can be blocked off for other application configurations.

<table>
<thead>
<tr>
<th>Manifold Packages</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manifold Bundle, 15-Foot, 6-Inch Spacing</td>
<td>148-371K</td>
</tr>
<tr>
<td>Manifold Bundle, 15-Foot, 7.5- and 8-Inch Spacing</td>
<td>148-375K</td>
</tr>
<tr>
<td>Manifold Bundle, 15-Foot, 10-Inch Spacing</td>
<td>148-377K</td>
</tr>
<tr>
<td>Manifold Bundle, 15-Foot, 15-Inch and Twin Row</td>
<td>148-379K</td>
</tr>
<tr>
<td>Manifold Bundle, 20-Foot, 6-Inch Spacing</td>
<td>148-372K</td>
</tr>
<tr>
<td>Manifold Bundle, 20-Foot, 7.5- and 8-Inch Spacing</td>
<td>148-376K</td>
</tr>
<tr>
<td>Manifold Bundle, 20-Foot, 10-Inch Spacing</td>
<td>148-378K</td>
</tr>
<tr>
<td>Manifold Bundle, 20-Foot, 15-Inch and Twin Row</td>
<td>148-380K</td>
</tr>
</tbody>
</table>

Fertilizer Tines
Each package includes one fertilizer tine all the hardware and plumbing needed to mount the tine. The tines mount on the tillage coulters and are adjustable for precise application.

<table>
<thead>
<tr>
<th>Package</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coil Tine Fertilizer</td>
<td>204-242K</td>
</tr>
</tbody>
</table>
Markers

Hydraulic markers are available. The units have a cast hub, tapered roller bearings and a bolt-on blade to leave a mark for you to follow on the next field pass. The markers are tied together hydraulically through a sequence valve for easy operation on one hydraulic circuit.

For information on how to adjust the markers, refer to “Liquid Fertilizer Arm” on page 38. For information on maintaining the markers, refer to “Lubrication” on page 45.

To order marker attachments, contact your Great Plains dealer.

<table>
<thead>
<tr>
<th>Markers</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-Foot All Seeds Dual Markers</td>
<td>113-469A</td>
</tr>
<tr>
<td>20-Foot All Seeds Dual Markers</td>
<td>113-470A</td>
</tr>
</tbody>
</table>
## Specifications and Capacities

<table>
<thead>
<tr>
<th></th>
<th>PH-15</th>
<th>PH-20</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coulter Spacing, Inches</strong></td>
<td>6 7.5 8 10 15 Twin Row</td>
<td>6 7.5 8 10 15 Twin Row</td>
</tr>
<tr>
<td><strong>Coulters per Hitch</strong></td>
<td>30 24 22 18 12 12</td>
<td>40 32 30 24 16 16</td>
</tr>
<tr>
<td><strong>Weight in Pounds</strong></td>
<td>6950 6560 6430 6170 5780 5780</td>
<td>7735 7215 7085 6695 6175 6175</td>
</tr>
<tr>
<td><strong>Working Width</strong></td>
<td>15 feet</td>
<td>20 feet</td>
</tr>
<tr>
<td><strong>Transport Width</strong></td>
<td>15 feet 4 inches</td>
<td>20 feet</td>
</tr>
<tr>
<td><strong>Length, Hitch Alone</strong></td>
<td>12 feet 1 3/4 inches</td>
<td>12 feet 1 3/4 inches</td>
</tr>
<tr>
<td><strong>Length with Drill</strong></td>
<td>18 feet 1 3/4 inches</td>
<td>18 feet 1 3/4 inches</td>
</tr>
<tr>
<td><strong>Transport Height with Tanks</strong></td>
<td>7 feet 5 inches</td>
<td>7 feet 5 inches</td>
</tr>
<tr>
<td><strong>Transport Clearance, Coulters</strong></td>
<td>16 1/4 inches</td>
<td>16 1/4 inches</td>
</tr>
<tr>
<td><strong>Transport Clearance, Drill Openers</strong></td>
<td>17 inches</td>
<td>17 inches</td>
</tr>
<tr>
<td><strong>Transport Tires</strong></td>
<td>11L x 15, 18-Ply</td>
<td>11L x 15, 18-Ply</td>
</tr>
<tr>
<td><strong>Tractor Requirements</strong></td>
<td>Two hydraulic remotes (four outlets); 110 - 150 horsepower</td>
<td>Two hydraulic remotes (four outlets); 145 - 185 horsepower</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>PFH-15</th>
<th>PFH-20</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coulter Spacing, Inches</strong></td>
<td>6 7.5 8 10 15 Twin Row</td>
<td>6 7.5 8 10 15 Twin Row</td>
</tr>
<tr>
<td><strong>Coulters per Hitch</strong></td>
<td>30 24 22 18 12 12</td>
<td>40 32 30 24 16 16</td>
</tr>
<tr>
<td><strong>Weight in Pounds</strong></td>
<td>8160 7686 7528 7212 6738 6738</td>
<td>9125 8493 8335 7861 7229 7229</td>
</tr>
<tr>
<td><strong>Working Width</strong></td>
<td>15 feet</td>
<td>20 feet</td>
</tr>
<tr>
<td><strong>Transport Width</strong></td>
<td>15 feet 4 inches</td>
<td>20 feet</td>
</tr>
<tr>
<td><strong>Length, Hitch Alone</strong></td>
<td>12 feet 1 3/4 inches</td>
<td>12 feet 1 3/4 inches</td>
</tr>
<tr>
<td><strong>Length with Drill</strong></td>
<td>18 feet 1 3/4 inches</td>
<td>18 feet 1 3/4 inches</td>
</tr>
<tr>
<td><strong>Transport Height with Tanks</strong></td>
<td>7 feet 5 inches</td>
<td>7 feet 5 inches</td>
</tr>
<tr>
<td><strong>Transport Clearance, Coulters</strong></td>
<td>16 1/4 inches</td>
<td>16 1/4 inches</td>
</tr>
<tr>
<td><strong>Transport Clearance, Drill Openers</strong></td>
<td>17 inches</td>
<td>17 inches</td>
</tr>
<tr>
<td><strong>Transport Tires</strong></td>
<td>11L x 15, 18-Ply</td>
<td>11L x 15, 18-Ply</td>
</tr>
<tr>
<td><strong>Tractor Requirements</strong></td>
<td>Two hydraulic remotes (four outlets); 110 - 150 horsepower</td>
<td>Two hydraulic remotes (four outlets); 145 - 185 horsepower</td>
</tr>
</tbody>
</table>

* Listed weights include fertilizer options on the PFH models and marker attachments on all models
** Horsepower requirements will vary with field conditions, terrain and optional attachments.

## Tire Warranty

All tires are warranted by the original manufacturer of the tire. Tire warranty information can be found in the brochures included with your Operator's and Parts Manuals or online at the manufacturer's websites. For service assistance or information, contact your nearest Authorized Farm Tire Retailer.

Manufacturer Websites
- Firestone [www.firestoneag.com](http://www.firestoneag.com)
- Goodyear [www.goodyearag.com](http://www.goodyearag.com)
- Titan [www.titan-intl.com](http://www.titan-intl.com)
- Gleason [www.gleasonwheel.com](http://www.gleasonwheel.com)
Figure 43
Specification Drawing
# Appendix

## Torque Values Chart

<table>
<thead>
<tr>
<th>Bolt Size</th>
<th>Grade 2</th>
<th>Grade 5</th>
<th>Grade 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>in-tpia(^a)</td>
<td>N-m(^b) ft-lb(^d)</td>
<td>N-m</td>
<td>ft-lb</td>
</tr>
<tr>
<td>1/4-20</td>
<td>7.4</td>
<td>5.6</td>
<td>11</td>
</tr>
<tr>
<td>5/32-28</td>
<td>8.5</td>
<td>6.0</td>
<td>13</td>
</tr>
<tr>
<td>5/32-18</td>
<td>15</td>
<td>11</td>
<td>24</td>
</tr>
<tr>
<td>3/16-24</td>
<td>17</td>
<td>13</td>
<td>26</td>
</tr>
<tr>
<td>3/16-14</td>
<td>27</td>
<td>20</td>
<td>42</td>
</tr>
<tr>
<td>1/4-14</td>
<td>31</td>
<td>22</td>
<td>47</td>
</tr>
<tr>
<td>5/32-14</td>
<td>43</td>
<td>32</td>
<td>67</td>
</tr>
<tr>
<td>5/32-20</td>
<td>49</td>
<td>36</td>
<td>75</td>
</tr>
<tr>
<td>1/2-12</td>
<td>66</td>
<td>49</td>
<td>105</td>
</tr>
<tr>
<td>9/32-18</td>
<td>75</td>
<td>55</td>
<td>115</td>
</tr>
<tr>
<td>5/16-12</td>
<td>95</td>
<td>70</td>
<td>150</td>
</tr>
<tr>
<td>5/16-16</td>
<td>105</td>
<td>79</td>
<td>165</td>
</tr>
<tr>
<td>3/8-16</td>
<td>130</td>
<td>97</td>
<td>205</td>
</tr>
<tr>
<td>3/8-18</td>
<td>150</td>
<td>110</td>
<td>230</td>
</tr>
<tr>
<td>7/32-10</td>
<td>235</td>
<td>170</td>
<td>360</td>
</tr>
<tr>
<td>5/32-16</td>
<td>260</td>
<td>190</td>
<td>405</td>
</tr>
<tr>
<td>7/32-9</td>
<td>225</td>
<td>165</td>
<td>585</td>
</tr>
<tr>
<td>5/32-14</td>
<td>250</td>
<td>185</td>
<td>640</td>
</tr>
<tr>
<td>1-8</td>
<td>340</td>
<td>250</td>
<td>875</td>
</tr>
<tr>
<td>1-12</td>
<td>370</td>
<td>275</td>
<td>955</td>
</tr>
<tr>
<td>1/8-7</td>
<td>480</td>
<td>355</td>
<td>1085</td>
</tr>
<tr>
<td>1/8-12</td>
<td>540</td>
<td>395</td>
<td>1210</td>
</tr>
<tr>
<td>1/4-7</td>
<td>680</td>
<td>500</td>
<td>1520</td>
</tr>
<tr>
<td>1/4-12</td>
<td>750</td>
<td>555</td>
<td>1680</td>
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<tr>
<td>3/8-6</td>
<td>890</td>
<td>655</td>
<td>1990</td>
</tr>
<tr>
<td>3/8-12</td>
<td>1010</td>
<td>745</td>
<td>2270</td>
</tr>
<tr>
<td>1/2-6</td>
<td>1180</td>
<td>870</td>
<td>2640</td>
</tr>
<tr>
<td>1/2-12</td>
<td>1330</td>
<td>980</td>
<td>2970</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bolt Size</th>
<th>Class 5.8</th>
<th>Class 8.8</th>
<th>Class 10.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm x pitch(^c)</td>
<td>N-m(^b) ft-lb</td>
<td>N-m</td>
<td>ft-lb</td>
</tr>
<tr>
<td>M5 X 0.8</td>
<td>4</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>M6 X 1</td>
<td>7</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>M8 X 1.25</td>
<td>17</td>
<td>12</td>
<td>26</td>
</tr>
<tr>
<td>M8 X 1</td>
<td>18</td>
<td>13</td>
<td>28</td>
</tr>
<tr>
<td>M10 X 1.5</td>
<td>33</td>
<td>24</td>
<td>52</td>
</tr>
<tr>
<td>M10 X 0.75</td>
<td>39</td>
<td>29</td>
<td>61</td>
</tr>
<tr>
<td>M12 X 1.75</td>
<td>58</td>
<td>42</td>
<td>91</td>
</tr>
<tr>
<td>M12 X 1.5</td>
<td>60</td>
<td>44</td>
<td>95</td>
</tr>
<tr>
<td>M12 X 1</td>
<td>90</td>
<td>66</td>
<td>105</td>
</tr>
<tr>
<td>M14 X 2</td>
<td>92</td>
<td>68</td>
<td>145</td>
</tr>
<tr>
<td>M14 X 1.5</td>
<td>99</td>
<td>73</td>
<td>155</td>
</tr>
<tr>
<td>M16 X 2</td>
<td>145</td>
<td>105</td>
<td>225</td>
</tr>
<tr>
<td>M16 X 1.5</td>
<td>155</td>
<td>115</td>
<td>240</td>
</tr>
<tr>
<td>M18 X 2.5</td>
<td>195</td>
<td>145</td>
<td>310</td>
</tr>
<tr>
<td>M18 X 1.5</td>
<td>220</td>
<td>165</td>
<td>350</td>
</tr>
<tr>
<td>M20 X 2.5</td>
<td>280</td>
<td>205</td>
<td>440</td>
</tr>
<tr>
<td>M20 X 1.5</td>
<td>310</td>
<td>230</td>
<td>650</td>
</tr>
<tr>
<td>M24 X 3</td>
<td>480</td>
<td>355</td>
<td>760</td>
</tr>
<tr>
<td>M24 X 2</td>
<td>525</td>
<td>390</td>
<td>830</td>
</tr>
<tr>
<td>M30 X 3.5</td>
<td>960</td>
<td>705</td>
<td>1510</td>
</tr>
<tr>
<td>M30 X 2</td>
<td>1060</td>
<td>785</td>
<td>1680</td>
</tr>
<tr>
<td>M36 X 3.5</td>
<td>1730</td>
<td>1270</td>
<td>2650</td>
</tr>
<tr>
<td>M36 X 2</td>
<td>1880</td>
<td>1380</td>
<td>2960</td>
</tr>
</tbody>
</table>

a. in-tpi = nominal thread diameter in inches-threads per inch  
b. N m = newton-meters  
c. mm x pitch = nominal thread diameter in mm x thread pitch  
d. ft-lb = foot pounds

Torque tolerance + 0%, -15% of torquing values. Unless otherwise specified use torque values listed above.
Hydraulic Schematics

Figure 44
Standard Hydraulics
Figure 45
Hydraulics with Coulter Command
Great Plains (a division of Great Plains Manufacturing, Inc.) warrants to the original purchaser that this Great Plains machine will be free from defects in material and workmanship for a period of one year (Parts & Labor) from the first use date when used as intended for personal use; ninety days for custom/commercial or rental use.

Second year limited warranty covers Parts ONLY (personal usage only, excluding labor and wear items). This warranty is limited to the replacement of any defective part by Great Plains. Great Plains reserves the right to inspect any equipment or part which are claimed to have been defective in material or workmanship.

The following items and/or conditions are **NOT COVERED UNDER WARRANTY:** Failures resulting from the abuse or misuse of the equipment, failures occurring as a result of accidental damage or Force Majeure, failures resulting from alterations or modifications, failures caused by lack of normal maintenance as outlined in the operator’s manual, repairs made by non-authorized personnel, items replaced or repaired due to normal wear (such as wear items and ground-engaging components including, but not limited to, disc blades, chisel points, tires, bushings, and scrapers), repeat repair due to improper diagnosis or improper repair by the dealer, temporary repairs, service call and/or mileage to and from customer location, overtime premium, or unit hauling expenses. The warranty may be voided if the unit is towed at speeds in excess of 20 miles per hour (32 kilometers per hour), or failures occurring from soils with rocks, stumps, or other obstructions.

Great Plains reserves the right to make changes in materials or design of the product at any time without notice. The warranty shall not be interpreted to render Great Plains liable for damages of any kind, direct or consequential or contingent to property. Furthermore, Great Plains shall not be liable for damages resulting from any cause beyond its control. This warranty does not extend to crop loss, losses caused by planting or harvest delays or any expense or loss of labor, supplies, rental machinery, or for any other reason.

No other warranty of any kind whatsoever expressed or implied, is made with respect to this sale; and all implied warranties of merchantability and fitness for a particular purpose which exceed the obligations set forth in this written warranty are hereby disclaimed and excluded from this sale.

This warranty is not valid unless registered by a certified Great Plains dealer.

Effective July 15, 2020