PIVOT IRRIGATION

Training Manual

pivotproag.ca

CHAPTER 1 -- SAFETY

Alberta can have a wide variety of environmental and physical hazards -- sometimes all in the same day. Being prepared before you head out is your first line of defence.

ENVIRONMENTAL HAZARDS

- Dress in layers that can be added and removed. Wear a hat, wear gloves, and keep extra clothing in the truck. We can go from snow in the morning to thirty-degree heat in the same afternoon.
- Keep an eye on the weather. High wind or lightning off in the distance means today may not be the right time to service this machine.
- A slight rain can make your boots muddy and slippery on metal surfaces. Make sure you have a firm grip and your footing is secure before climbing.

ANIMAL HAZARDS

You are working alone and isolated. Keep a clear head and identify any animals that could present a threat.

- Check panels inside, outside, and underneath for spiders before putting your hands in. Black widows and recluse spiders are present in southern Alberta -- their bites can cause permanent damage.
- Wear boots with ankle support, socks that cover your ankles, and pants -- not shorts. Many fields are rife with ticks, which carry diseases that can be detrimental to your health.
- Cattle -- drive past them slowly. You can startle them, cause them to run, break a leg, or trample you in the effort to get away.
- Predators are around in Alberta. Bobcats and mountain lions follow the canals. Coyotes have been interbreeding with wolves and are not as shy as they used to be. Be aware and avoid them. The neighbour's dog usually relaxes if you offer him a cookie.

ELECTRICAL HAZARDS

Electricity is dangerous. It is always best practice to work on pivots with the power off -- however that is not always an option. Sometimes a fault only appears occasionally and you may need to work on a live machine.

- Never touch bare wire or contacts on a live component. Use a multimeter and non-conductive tools only. Even neutral and ground can carry voltage in certain fault scenarios.
- Do not lean against or rest your arm on an open panel door. Circuitry can extend to the front panel and it is easy to contact a switch when it is to your side.
- Before opening any panel, touch the outside with the back of your hand. If something has gone wrong, your hand will pull back away from the panel rather than grip it.

- Use your meter. Get a full picture of all voltages and connections before touching anything.
- Minimize risk by removing the pivot's ability to move, or by bypassing wet circuits so you can examine components safely. Slips are the number one cause of electrocutions.
- If you are not comfortable working on something -- water leaking in, actively raining -- shut the power off and come back when it has dried out.

GENERAL SAFETY REMINDERS

- Keep a first aid kit in your truck at all times.
- Wear gloves and appropriate protective gear.
- Take your time. Accidents happen when you rush.

CHAPTER 2 -- THE PIVOT AND COMMON COMPONENTS

Section 1 -- The Seven Circuits

The electric center pivot is the most common design in southern Alberta. Your basic seven-tower pivot relies on seven circuits working together to function:

1. Three-phase circuit -- determines the direction the drives turn
2. Run/Stop or Forward/Reverse circuit -- determines when a tower moves or stops
3. Safety circuit -- shuts the pivot down if it loses alignment
4. Percent circuit -- makes the end tower move or stop
5. End-gun circuit -- runs the end gun or an accessory
6. Neutral circuit -- provides neutral for components run with a coil
7. Ground circuit -- a safety protocol required on all devices using electricity and water

Section 2 -- How an Electric Pivot Moves

1) When you hit the start button, the pivot first checks its safety line to ensure it is safe to move.
2) If the safety return is received, the panel enables a contactor to send three-phase power out on the system.
3) In each tower box the components are already set up to allow for movement.
4) In the end tower box, the safety loops back to the panel on the safety wire, and the percent circuit ends at the contactor.
5) As the percent timer cycles, it applies or removes the voltage needed to open and close the end tower contactor.
6) Inside towers stay aligned with the end tower using microswitches. When the outside tower moves far enough, the microswitch engages, closes the contactor, and drives the motor.
7) After the tower moves back into alignment, the microswitch disengages, cutting power and stopping movement.
8) A switch or controller engages and disengages the end-gun by applying voltage to a contactor at the end of the machine.

Section 3 -- Common Pivot Components

Transformer -- Usually a 4:1 step-down, 480V to 120V (some brands also provide 24V). Supplies power to the pivot's control circuits.

Contactors -- Open and close the three-phase circuit for whatever product needs it. The panel forward/reversing contactor sets directional phasing. Tower box contactors simply close the connection in the direction the panel has set.

Relays -- Allow control of components under conditions you set, convert control power, or isolate a circuit from the machine.

Microswitches -- Set very finely in tower boxes so that when the outside tower flexes at the joint, they engage and disengage the contactor. Also used on switches at the pivot point on mechanical panels.

Center-drives -- When powered by the contactors, turn one direction or the other. Connected by a rod to the gearbox which turns the pivot's wheels.

Gearboxes -- Turned by the center drive to rotate the wheels.

Collector Ring (Reel) -- Allows circuits to send signals on the span wire to the tower boxes as the pivot rotates. Brushes drag along brass rings to maintain an electrical connection to the machine. Very common place to lose connection on old machines, check brushes and rings for grime yearly.

Pivot Controller -- Mechanical or computer-based, usually mounted to the center tower. Controls circuits by sending out the signals and power needed to run all components.

Percent Timer -- On mechanically controlled pivots, sends out the end-tower movement signal. Based on a 60-second cycle -- 50% means on for 30 seconds, off for 30 seconds.

Booster Pump -- Controlled by a switch at center or via GPS/computer. Turns on and off when the end-gun circuit signals it.

Overwater (Stall) Timer -- Counts down if the end tower contactor does not come in for a set period, indicating the tower has stopped. Shuts down the machine.

Pressure Switch / Transducer -- The pressure switch tells the panel when water is present. A transducer performs the same function for computer panels and allows programming of pump settings based on its readout.

Solenoid -- Activated by a coil to switch contacts for water or air to control a valve. Found at the Nelson valve, end gun, and shut-off points.

Section 4 -- Ohm's Law

V = I x R

V = Voltage (volts) -- the pressure pushing electricity through a circuit

I = Current (amps) -- the amount of electricity actually flowing

R = Resistance (ohms) -- how much the circuit fights that flow

Think of it like water in a pipe: voltage is the water pressure, amps is how much flows, and resistance is how narrow the pipe is.

- If resistance stays the same, more voltage = more amps. Push harder, more flows.
- If voltage stays the same, more resistance = fewer amps. Narrow the pipe, less flows.
- If voltage stays the same and amps increase, resistance has dropped unexpectedly -- often a short circuit.

Why it matters on a pivot

A motor pulling more amps than it should means it is working harder than designed -- mechanically bound up, low voltage at the panel, or a failing winding. Amps are your window into what is actually happening. You cannot always see a problem, but you can always measure it.

CHAPTER 3 -- THE CIRCUITS

Section 1 -- The Three-Phase Circuit

Three-phase power comes into the panel and first goes to the disconnect -- a switch on the front of the panel that requires you to break the three-phase circuit before the door opens.

- Two legs tap off to the transformer to supply 480V control power.
- All three legs go to the contactors. One side wired 1-2-3, the other 1-3-2 -- this phase swap sets the direction of tower motor rotation.
- When the contactor closes, three-phase is sent to the collector reel and redirected out onto the machine.
- On the span wire, three-phase powers all tower boxes and can run the booster pump box in either direction via its own forward/reversing contactor.

Section 2 -- Run/Stop Forward/Reverse Circuit

These wires control the switches that keep the pivot in alignment. When started in forward or reverse, the panel gives voltage to the appropriate wire, which passes through the collector ring to the tower boxes.

In each tower box, the forward and reverse lines go to the back of the alignment microswitch -- one to the normally open contact, one to the normally closed. The contactor coil connects to the common contact. When moving forward, each time the microswitch contacts forward and common, the contactor closes and the tower moves.

> **Best Practice -- Setting Alignment**
> Start the first tower, remove the three-phase wires from the contactor, move the second tower into alignment at the panel, then continue tower by tower. Once all towers are straight, set the microswitches and rewire the contactors. Always turn off the disconnect before wiring three-phase.

R-Style Alignment

Two switches stacked -- top is safety, bottom is alignment (purple, pink, red wires; common goes to the contactor).

1) Turn the thumbscrews in or thumbs out to activate or deactivate the switch, you can see which way to turn the cogs but just pressing down the switch. If it doesn't click you need to make the cog go the other way
2) Watch the bottom lever until it clicks and activates the switch.
3) Turn thumbscrews the other way, counting quarter-turns until the switch clicks back out. Set to exactly the halfway point. (3 quarter-turns = go back 1.5; 8 quarter-turns = go back 4.)
4) Test by gently pushing the lever one way then the other -- it should click and hold in position until you move it the other way.

5) Reset the safety switch: loosen the screw on top, align it in the V, retighten.

V-Style Alignment

Two switches attached to the box bottom with a three-pronged cog. Wires: brown, orange, yellow-red.

1) Loosen the half-inch bolts on the control arm. Find the switch that has three wires Brown, Orange, and Yellow, this is the switch we are setting. You can push, or pull the alignment arm to figure out which way you need to set the adjustment bolt at the end of the alignment arm.
2) Use the bolt and eyelet at the end of the alignment rod to push or pull until the switch clicks.
3) Find the midpoint between click-in and click-out points on the microswitch. To do this turn the alignment nut on the alignment rod's alignment bolt against the eyelet. This will turn the cog that activates the switch turn it until it either clicks in or out and stop. Now turn the nut the other way and count your quarter turns until it clicks again, if you've made four quarter turns, go back two. We want to be in the middle of where that switch clicks in to activate and out to disengage.
4) Tighten the alignment rod nuts back up and you should be able to test it by giving the alignment rod a push, or a pull. Like with the other R-style box you should be able to click that switch back and forth without much force.
5) If the switch doesn't click in, or if it clicks back out by itself, you don't have it really set. However you can use the adjustment screw on the microswitch itself to fine tune it.

Z-Style Alignment

This alignment is really simple, generally all you have to do is get the machine straight as instructed above. Then use the alignment rod and nuts underneath the box to set your safety switch directly in the middle. 95% of the time this is all you need to do, however if one switch is a little different and a tower seems to be ahead

1) Get the pivot back in to alignment
2) Just like in the other two methods we need to find the middle of the travel of the switch between where it clicks in and out. On this system we are looking at the long arm microswitch with yellow, pink, and a wire from common to the coil of the contactor.
3) Turn the nuts on the alignment rod to either push or pull away from the switch until it clicks
4) Adjust the alignment rod the other way by quarter turns and count them until it clicks the other way.
5) Go back half the travel, if you've turned four quarter turns between clicks, go back two
6) Test your switch you should be able to push and pull the alignment rod for the switch to click and stay in, like the other two systems above, if it doesn't click, or clicks in and back out, we don't have it perfect yet.

> **Compatibility Note**
> V-Style switches can be used on R-Style boxes. R-Style switches can be used on V-Style boxes -- you lose the set screw but alignment can still be set via the control arm underneath.

Safety Note

When you are done setting alignment always make sure the safety switch is in the middle of it's valley on the cog.

Section 3 -- Safety Circuit

The safety circuit tells the controller when the pivot has lost alignment, triggering a shutdown of the pivot and the pump. The panel sends a signal out through the machine that loops back through the tower microswitches.

V-Style Safety

Panel sends 120V out on yellow-red. Wire travels uninterrupted to the end of the machine, loops back to the safety return on yellow, and passes through the overwater timer and all microswitches. On a mechanical panel, this closes the three-second safety board, enabling contactors. On a computer panel, it feeds an input confirming safety.

R-Style Safety

Uses neutral going out on the machine to loop back on safety in the last tower. Returns through the overwater timer and all microswitches. On mechanical panels it feeds neutral to the contactors. On newer blue panels, a safety relay closes neutral and power for the contactors -- when it drops out, everything stops.

Z-Style Safety

Uses the forward and reverse wires as the safety-out. A relay in the last tower feeds power back on the safety return line, passing through the overwater timer and all microswitches. A safety relay at the main panel (bottom right, open-face -- you can watch the contacts move) passes power to the control circuit.

Section 4 -- Percent Circuit

The percent circuit is the same on every pivot. It runs from the panel through the collector ring directly to the end tower contactor. As this tower moves, all others follow it around the field.

Troubleshooting Tip

If the pivot is not moving, start here. Do you have 120V on the percent wire when running? Is the end tower contactor turning on and off with that signal? If there is a light on this circuit it reads very low resistance -- unwire it to isolate the circuit when looking for a short.

Section 5 -- End-Gun Circuit

The end-gun circuit is controlled by a switch at the center point that rotates with the pivot -- ramp switches or a star switch on mechanical panels, or GPS/resolver-based on computer panels. The circuit leaves the panel, travels through the collector ring, and connects to the end tower solenoid or booster pump box.

V-Style End Gun

1) The booster pump box is the end tower box on this system.
2) Its F/R contactor passes three-phase 1-2-3 at rest. When the forward wire is live it energizes the coil and switches two phases.
3) That contactor feeds three-phase to a second contactor which powers the end gun.
4) A pressure switch protects the circuit -- no water, no power. Check this first if the booster pump won't come on.
5) A solenoid opens and closes the valve for the end gun.

R-Style and Z-Style End Gun

1) Star switch, ramp switch, or computer panel passes power down the machine to a solenoid or booster pump box at the end.
2) A relay turns on and off with the end-gun wire, passing forward or reverse power to the appropriate side of the F/R contactor.
3) Also protected by a pressure switch.
4) A solenoid opens and closes the valve for the end gun.

Section 6 -- Neutral Circuit

The neutral circuit originates at the transformer, created by connecting neutral to ground at the transformer or via a wire to the ground lug. It is isolated from ground everywhere else on the pivot.

- Provides neutral to all coils on the machine.
- Should never show 120V. If it does, there is a problem with the neutral or ground.
- Every coil works via a voltage differential -- it needs neutral and a voltage input on its other terminal to close.

> **Troubleshooting Tip**
> If everything looks correct but a contactor still won't close, check the neutral side. If you measure 120V on the neutral terminal, it needs a proper connection back to neutral.

Section 7 -- Ground Circuit

The ground circuit is the most important part of the machine -- it is what keeps you safe. When a component fails, it connects to ground through either a direct connection or the neutral wire in the tower boxes. This shorts the system and pops the fuses (or trips the ground fault protection) before you can be harmed.

> **Important**
> Ground connects to neutral in the main panel. If you are having difficulty pinpointing a short, check the neutral wire -- a fault further down the machine may be feeding back through that connection.

APPENDIX -- REFERENCE CHARTS

A1 -- Wire Color Reference by Style

Wire Color Reference Chart

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CIRCUIT	V-Style	R-Style	Z-Style	L-Style
FORWARD	Brown	Purple	Pink *	Yellow
REVERSE	Orange	Pink	Yellow *	Orange
PERCENT	Purple	Orange	Orange	Purple
SAFETY IN	Yellow	Brown	Tan / Brown **	Pink
SAFETY OUT	Yellow / Red	N/A	Tan / Brown **	N/A
END GUN	Pink	Yellow	Purple	Brown

NOTES

* Z-Style Forward / Reverse: On older machines these wires may be opposite (Forward = Yellow, Reverse = Pink). Always verify before assuming direction.

** Z-Style Safety: On 10-wire machines, Safety Return is Brown. On older 11-wire machines, either Brown or Tan may be used -- one will be outgoing, one incoming.

You can identify the colour of the return wire by looking at a tower box to see which wire is connected to the microswitch -- that wire is your return wire.

V-Style Safety Out is a two-colour striped wire (Yellow + Red) -- do not confuse with plain Yellow (Safety In / Return).

Wire colours may vary slightly by machine age and manufacturer revision. Always verify with a meter.