

Power Take-Off (PTO) Safety

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The power take-off (PTO) shaft is an efficient means of transferring mechanical power between farm tractors and implements. This power transfer system helped revolutionize North American agriculture during the 1930s. It is also one of the oldest and most persistent hazards associated with farm machinery. This fact sheet discusses several aspects of PTO safety.

Components of an Implement

Power Take-Off

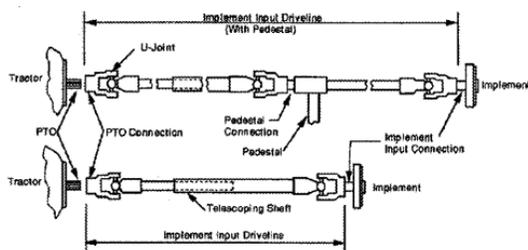


Figure 1. The major components of PTO systems

Figure 1 is a diagram of component parts of an implement PTO to better understand PTO hazards, guarding, and injuries. The upper drawing is of a PTO system involving a pedestal connection as found on many types of pulled machinery (e.g., hay balers, forage choppers, large rotary mowers, etc.). The bottom drawing is of a PTO system where the implement's input driveline connects directly to the tractor PTO stub.

Examples of this type of connection include three-point hitch mounted equipment (e.g., post hole diggers, small rotary mowers, etc.) and augers. The flexible universal joint or "U joint" makes the connection from the tractor to the implement. U Joints are connected by a square rigid shaft which turns inside another shaft.

PTO Hazards

Power Take-off (PTO) Stub

The tractor's stub shaft, often called the PTO, transfers power from the tractor to the PTO-driven machine or implement. Power transfer is accomplished by connecting a drive shaft from the machinery to the tractor's PTO stub shaft. The PTO and drive shaft rotate at 540 rpm (9 times/second) or 1,000 rpm (16.6 times/second) when operating at full recommended speed. At all speeds, they rotate in proportion to the speed of the tractor engine. Note: 1000 rpm speed PTO shafts have more splines on the shaft.

Most incidents involving PTO stubs result from clothing caught by an engaged but unguarded PTO stub. The reasons a PTO stub may be left engaged include: the

operator forgetting or not being aware of the PTO clutch is engaged; seeing the PTO stub spinning but not considering it dangerous enough to disengage; or, the operator is involved in a work activity requiring PTO operation. Boot laces, pant legs, overalls and coveralls, and sweatshirts are clothing items that can become caught and wrapped around a spinning PTO stub shaft. In addition to clothing, additional items that can become caught in the PTO include jewelry and long hair.

Power Take-Off (PTO) Drivelines

The PTO driveline is identified as a mechanical wrap point hazard and is one of the oldest and most common farm machinery hazards, referring specifically to the part of the implement (machine) drive shaft that connects to the tractor (Figure 2).

This drive shaft is known as the implement input driveline



Figure 2. Driveline connected to the tractor

(IID). The entire IID shaft is a wrap point hazard if the IID is completely unshielded. If the IID shaft is partially guarded, the shielding is usually over the straight part of the shaft, leaving the universal joints, the PTO connection (front connector), and the Implement Input Connections (IIC, the rear connector) as the wrap point hazards. Protruding pins and bolts used as

connection locking devices are particularly adept at snagging clothing. If clothing does not tear or rip away, as it sometimes does for the fortunate, a person's limb or body may begin to wrap with the clothing. Even when wrapping does not occur, the affected part may become compressed so tightly by the clothing and shaft that the person is trapped against the shaft.

The machine's IID shaft is coupled to the tractor's PTO stub. Therefore, it too rotates at either 540 rpm (9 times/second) or 1,000 rpm (16.6 times/second) at full speed. At these speeds, clothing is pulled around the IID shaft much quicker than a person can pull back or take evasive action. Many IID shaft entanglements happen while the shaft is turning at one-half or one-quarter of the recommended operating speed. Even with a relatively quick reaction time of five-tenths of a second, the wrapping action has begun. Once wrapping begins, the person instinctively tries to pull away. This action simply results in a tighter, more binding wrap. The 1,000 rpm shaft roughly cuts in half the opportunity for evasive action. Simply put, our reaction time is slower than the speed of the turning PTO shaft.

PTO power machinery may be engaged while no one is on the tractor for several reasons. Some PTO powered farm equipment is operated in a stationary position so the operator only needs to start and stop the equipment. Examples of this type of equipment include elevators, grain augers, and silage blowers. At other times, adjustments or malfunction of machine

components can only be made or found while the machine is operating.

Additionally, many work practices such as clearing a plugged machine leads to operator exposure to operating PTO shafts. Other unsafe practices include mounting, dismounting, reaching for control levers from the rear of the tractor, and stepping across the shaft instead of walking around the machinery. An extra rider while PTO power machinery is operating is another exposure situation.

The wrap point hazard is not the only hazard associated with IID shafts. Serious injury has occurred when shafts have become separated while the tractor's PTO was engaged. The machine's IID shaft is a "telescoping shaft". That is, one part of the shaft will slide into a second part. This shaft feature provides a sliding sleeve which greatly eases the hitching of PTO powered machines to tractors, and allows telescoping when turning or moving over uneven ground. If an IID shaft is coupled to the tractor's PTO stub but no other hitch is made between the tractor and the machine, then the tractor may pull the IID shaft apart. If the PTO is engaged, the shaft on the tractor end will swing wildly and may strike anyone in range. The swinging force may break a locking pin allowing the shaft to become a flying missile, or it may strike and break something that is attached or mounted on the rear of the tractor. Separation of the driveline shaft is not a commonly occurring event but is most likely to happen when three-point hitched equipment is improperly mounted or

aligned, or when the hitch between the tractor and the attached machine breaks or accidentally uncouples.

PTO Entanglement Incidents

Although PTO entanglement incidents have decreased over time compared with other causes of farm fatalities, Pennsylvania statistics over a recent ten year period records five fatalities showing that attention to PTO safety continues to be important.

PTO Guards

Guarding a PTO system includes a "master shield" for the tractor PTO stub and connection end of the implement input driveline (IID) shaft, an integral-journal shield which guards the IID shaft, and an implement input connection (IIC) shield on the implement. The PTO master shield is attached to the tractor and extends over and around the



PTO stub on three sides (Figure 3). This

Figure 3. Master shield

shield is designed to offer protection from the PTO stub and the front joint of the drive shaft of the connected machine. Many tractors, particularly older tractors, may no longer have PTO master shields. Master shields are removed or are missing from tractors for several reasons including: damaged shields that are never replaced; shields removed for convenience of attaching machine drive shafts; shields

removed out of necessity for attaching machine drive shafts; and shield missing when used tractors are sold or traded.

There are more injuries associated with the IID shaft than with the PTO stub. As noted earlier, machine drive shaft guards are often missing. This occurs for the same reasons tractor master shields are often missing. An IID shaft guard completely encloses the shaft, and may be constructed of plastic or metal. These tube-like guards are mounted on bearings so the guard rotates with the shaft but will stop spinning when a person comes into contact with the guard. Some machines have driveline guards with a small chain attached to a non-rotating part of the machine to keep the shield from spinning. The most important thing to remember about a spinning IID shaft guard is that if the guard becomes damaged so that it cannot rotate independent of the IID shaft, its effectiveness as a guard is lost and it becomes as hazardous as an unguarded shaft. While the tractor is turned off, spin the IID shaft guard after attaching the PTO to the tractor. This is the best way to make sure that the IID shaft guard is really offering you protection.

PTO Entanglement Examples

These examples of PTO injury incidents involving Pennsylvania farmers will help illustrate the serious nature of PTO hazards:

Case #1: An operator finished loading a load of silage into the silo and was approaching the tractor's PTO lever to turn off the

forage blower. As he stepped onto the drawbar, the laces on his boot became caught on the spring loaded push pin of the forage blower PTO driveline coupling. He was thrown backwards off the drawbar, with this boot and denim jeans being forcibly removed. He suffered considerable muscle damage to his right leg.

Case #2: A teenager was helping her family load corn onto a grain elevator when her jacket sleeve became entangled by the elevator PTO shaft. Her body was flung around the shaft and her arm was torn from its socket before the tractor could be turned off.

Case #3: A small child was killed when as an "extra rider" on his father's tractor; he slipped off the tractor and became entangled by a spinning PTO shaft. The father grabbed for the boy as he began to slip but was unable to hold him out of the shaft.

Case #4: An operator's clothing was near a spinning shaft, pulled him in, flung him around the shaft a couple of times, and then threw him clear. He sustained injuries to his head, leg, right arm, and shoulder.

PTO Safety Practices

Though not always convenient or easy, there are several ways to reduce the risk of PTO injury incidents. These safety practices offer protection from the most common types of PTO entanglements.

- Keep all components of PTO systems shielded and guarded.
- Regularly test driveline guards by spinning or rotating them to ensure

that they have not become stuck to the shaft.

- Disengage the PTO and shut off the tractor before dismounting to clean, repair, service, or adjust machinery.
- Always walk around tractors and machinery instead of stepping over a rotating shaft.
- Always use the driveline recommended for your machine. Never switch drivelines among different machines.
- Position the tractor's drawbar properly for each machine used to help prevent driveline stress and separation on uneven terrain and during tight turns.
- Reduce PTO shaft abuse by observing the following: avoid tight turns that pinch rotating shafts between the tractor and machine; keep excessive telescoping to a minimum; engage power to the shaft gradually; and avoid over tightening of slip clutches on PTO-driven machines.
- Be sure PTO driveline is securely locked onto the tractor PTO stub shaft.

- Keep universal joints in phase. (If unfamiliar with this term, check the operator manual or talk with a farm implement dealer.)

Summary

Recognize that the PTO shaft turns at speeds that are faster than our reaction time. It is easy to get snagged into a turning PTO shaft. To prevent PTO entanglement with its potential for injury and death, follow these guidelines:

- Stop the tractor engine and disengage the PTO to work on the machine or unclog it.
- Keep guards in place.
- Wear close fitting clothing to prevent entanglement of loose clothing parts.
- Secure long hair under a hat when working around the PTO.
- Instruct all operators about the hazards of the PTO.
- Keep children away from all turning parts of the machine not just the PTO.

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