Cornell Cooperative Extension

RURAL
Safety and Health

POWER TAKE-OFF (PTO) SAFETY

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THIS FACT SHEET COVERS

The power take-off (PTO) drive, found on most farm tractors, is a major power source for agricultural equipment. The PTO system efficiently transfers mechanical power from the tractor to the implement, but it may present serious hazards to persons who are unfamiliar with its operation.

PTO Components

When hooked up to a piece of equipment, the complete PTO system or implement input driveline may connect either directly to the tractor spline or stub, or indirectly through a pedestal connection as illustrated in figure 1. Coupling devices are used to attach the shaft to the tractor and to the implement.

A spline collar slides over the tractor's spline, which extends from the tractor differential. The collar is held in place by a spring-loaded pin that latches into a recess on the spline. The telescoping feature of the shaft allows the collar to slide easily onto the spline. Together with the universal joints, the telescoping shaft allows the PTO system to flex and adjust when the tractor turns or travels over uneven terrain.

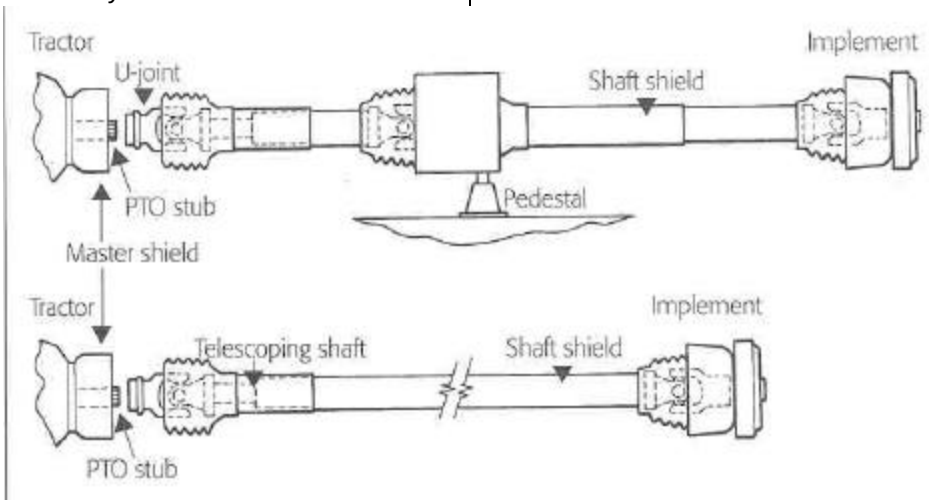

Fig. 1. PTO components

When operated at full recommended speed, a PTO shaft will rotate clockwise at 540 revolutions per minute (rpm), which equals 9 revolutions per second, or at 1,000 rpm (16.7 revolutions per second). As shown in the Table 1, a 540 rpm shaft travels 7.1 feet per second, while a 1,000 rpm shaft turns 13.1 feet per second. A person caught in a revolving PTO shaft has little chance to escape.

Shielding

Shields are essential to the safe operation of the PTO system. To prevent operators from coming in contact with spinning parts, every component of the PTO system should have guards, including a shaft shield, a master shield, and an implement shield.

Most modern shaft shields are tubular, although older equipment may have inverted U-shaped shielding devices. Tubular shields are recommended because U-shaped shields guard against contact only from the sides and top of the shaft. Metal or plastic tubular shields completely enclose the shaft. Bearings prevent the shield from spinning when contact is made. Some models use a chain connected to a stationary part of the machine to prevent the shield from spinning constantly. Even if tubular guards are in place, a hazard may exist if the shield is damaged and cannot spin independently from the shaft. A damaged guard can be as hazardous as an unguarded shaft.

The tractor's master shield and the implement shield are particularly important because they prevent equipment operators from getting entangled in the system's dangerous rotating connections. The master shield extends over the top and around the sides of the spline and protects the operator from the rotating spline and front universal joint. People become entangled in this area when boot laces or other articles of clothing catch on the locking pin, bolt, or grease fitting. The implement shield is similar in appearance to the master shield and offers protection from the rear universal joint and implement connection.

One or more of these shields are frequently missing. Operators sometimes remove shields because they make hitching up equipment inconvenient or impossible. They may remove damaged shields and not replace them. Shields may be missing when used tractors or equipment are purchased.

PTO Accidents

Most PTO accidents and injuries occur when a person's clothing or hair becomes entangled with a part of the spinning PTO system. Protruding components such as the locking pin, bolt, cotter pin, grease fitting, nails, universal joint, and tractor spline readily hook and grab loose or dangling clothes or hair. Boot laces, pant legs, coat or shirt cuffs and tails, drawstrings on windbreakers or hooded sweatshirts, and scarves

Table 1.
Lapsed Time vs. Distance Traveled

And how it relates to a tractor PTO turning at 540 and 1000 rpm–shaft/shield diameter of 3 inches

	540 RPM		1000 RPM	
Lapsed time in seconds	Revolutions Turned	Distance Traveled (ft.)	Revolutions Turned	Distsnce Traveled (ft.)
0.15	1.4	1.1	2.5	2.0
0.25	2.3	1.8	4.2	3.3
0.33	3.0	2.4	5.5	4.4
0.40	3.6	2.8	6.7	5.2
0.50	4.5	3.5	8.3	6.5
0.60	5.4	4.2	10.0	7.9
0.70	6.3	4.9	11.7	9.2
0.80	7.2	5.7	13.3	10.5
1.00	9.0	7.1	16.7	13.1
1.50	13.5	10.6	25.0	19.6
3.00	27.0	21.2	50.0	39.3
5.00	45.0	35.3	83.3	65.5
10.00	90.0	70.7	166.7	130.9
60.00	540.0	424.1	1000.0	785.4

frequently get entangled. Cases have also been reported of long hair getting caught in PTOs.

Once clothing or hair is caught, the PTO's speed of rotation, combined with the power exerted by the tractor, makes escape unlikely and injury almost certain. Following are some typical outcomes:

- Clothing is torn completely off the person, resulting in minor injuries such as friction burns, scrapes, sprains, and bruises.
- Clothing is torn away, and in the process the PTO catches and tears loose or hanging skin. Injury to the scrotal area is common with this type of accident.
- Clothing is torn away, and part of the victim's body becomes wrapped up in the shaft or wedged against the machine resulting in severe injury, including lacerations, broken bones, strangulation, loss of limbs, fingers, or toes.
- Clothing is not completely torn away, and the victim's body rotates with the shaft, causing multiple serious injuries or death.
- Hair becomes entangled, resulting in partial or complete scalping.

PTO accidents can happen when the tractor is moving or stationary. Under normal conditions, the PTO should be disengaged, cutting the power from the tractor, before the operator dismounts. There are several reasons, however, for keeping the PTO engaged when the tractor Is stationary:

- Some machines, such as augers and silage blowers, are designed for is stationary use of PTO power.
- Maintenance procedures such as lubricating chains, sharpening knives, or checking the condition of moving parts may require that power be run to the machine.
- On some older tractors it may be impossible to reach for control levers without coming in close proximity to the spinning PTO.

In all these situations the operator may be near the shaft, increasing the possibility of entanglement.

Accident Factors

The operator, the machine, and the environment can contribute singularly or together to a PTO accident.

The Operator

The physical and mental condition of the operator may lead to poor decision making, unsafe actions, or impaired capabilities. Age can affect both the physical and the mental condition of an operator. Young operators have limited experience and knowledge, and their lack of aware- ness of hazards increases the possibility of an accident. Older workers may be experienced but often have slower reaction times and lack the agility to react physically to some situations, particularly when the work area is slippery.

Farmers are often in a hurry to get a job done. But trying to rush or getting frustrated with delays and breakdowns can cause mental strain. Preoccupation with completing work or other distractions can divert attention from job hazards.

A person's attitude about safety is also very important in preventing accidents. Does the operator perceive PTO operation as hazardous? Does he or she take the time to install or replace missing guards? Does the operator knowingly or unknowingly place himself or herself in a hazardous situation, particularly when mounting, dismounting, or adjusting controls from the rear of the tractor? Knowledge of hazards alone is not enough to prevent accidents. A positive attitude about safety is needed to make use of the knowledge.

The Machinery

PTO accidents are not always the result of human error. Often the machinery may contribute to a PTO accident. The tractor or implement may have been purchased without shielding. Older tractors, designed to be mounted and dismounted from the rear, make it impossible for operators to avoid coming close to the PTO. Equipment that requires removing the master shield to tie onto the PTO may also present hazards to the operator.

The Environment

The environment may contribute to a PTO accident. Slippery conditions caused by rain, mud, snow, frost, or ice can cause an operator to lose his or her balance while mounting or dismounting a tractor or implement. Temperature extremes, noise, and vibration from the machine can adversely affect operators by reducing their physical capabilities or adding to mental strain. When working in a tight space, an operator may have to come close to the PTO or perform an activity differently than usual. Finally, because the home and workplace are often the same on a farmstead, children are regularly exposed to dangerous equipment, increasing the possibility of accidents for non-operators.

PTO Safety Precautions

- Whenever possible, shut the PTO off before dismounting the tractor.
- Keep all tractor and implement shields and decals in place. Re- place missing shields as soon as possible.
- Do not wear loose or bulky clothing around the PTO or other moving parts.
- Make sure all operators of PTO-driven equipment are trained and knowledgeable about safe operating procedures and hazards that may not be readily apparent.
- Be extra cautious when using stationary PTO-powered equipment.
- Periodically check on PTO operators to ensure a quick response in the event of an accident. Injuries that would not ordinarily be fatal can be life threatening if the victim is not found until hours later. PTO accident victims require immediate medical care.
- Always walk around equipment to avoid coming near an active PTO. Stepping over, leaning across, or crawling under a live PTO can lead to entanglement.

- Keep all bystanders away from PTO-driven equipment, and never allow children to ride on tractors or equipment.
- Position the tractor drawbar properly for each machine used to prevent driveline stress and separation.
- Regularly test the shaft guard by rotating it to ensure that it spins freely.

Summary

The PTO system is one of the most useful and most dangerous pieces of farm machinery. Entanglement with a PTO can result in dismemberment, scalping, or death. Shields for PTO components are essential for the systems safe operation.

Careful forethought should be given to taking precautions related to the environment, the machinery, and the operator. By adopting a positive approach to safety and following these guidelines, you can help ensure safe machine operation.

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