AgriLIFE EXTENSION
Texas A&M System

SAFE TRACTOR OPERATION: ROLLOVER PREVENTION

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If we cannot develop a U.S. model for a proven intervention on the single most important cause of agricultural mortality—tractor overturns—how can we succeed in addressing the less dramatic yet still important causes of agricultural diseases and injuries?

Dr. James Merchant, Dean, College of Public Health, University of Iowa, addressing the Surgeon-General's Conference on Agricultural Safety and Health, 1991.

July 17, 2004. A 16-year-old male died from injuries sustained when the tractor he was driving overturned. The tractor was not equipped with a rollover protection structure or a general purpose enclosed cab. The tractor was capable of traveling at a maximum speed of approximately 16 to 18 miles per hour. The victim drove west on a paved public highway that did not have shoulders. A passenger rode on the tractor to the driver's left, leaning against the tractor fender. As the victim drove down the highway, the right wheels of the tractor left the road surface. As the tractor traveled forward, the right wheels cut into the soft, grass-covered ditch. Tracks in the grass indicated the victim turned the steering wheel sharply to the left to drive the tractor back onto the road. When the right front wheel struck the edge of the paved road surface, the tractor suddenly turned nearly cross ways in the road. As a result of the speed of travel and the sudden turn to the left, the tractor overturned. The tractor rolled to the right side and came to rest in an inverted position on the road. The victim was pinned underneath the tractor and pronounced dead on the scene. The passenger was slightly injured when he was thrown clear of the tractor and landed in the ditch. *Source: Minnesota FACE 94MN039.*

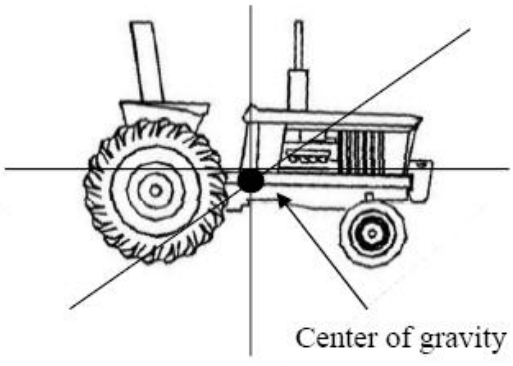
TRACTOR FATALITIES

According to the National Institute for Occupational Safety and Health (NIOSH), approximately 250 people per year are killed as a result of agricultural tractor rollovers, runovers, entanglements, and highway collisions. Rollovers account for more than half of these fatalities, despite decades of effort by tractor manufacturers and farm safety professionals to eliminate these tragedies. One of the most effective means to prevent injury from rollovers is to operate tractors equipped with rollover protective structures while wearing a seatbelt.

The causes of rollover fatalities are diverse and involve the inherent risks on farms and farm operations, economic limitations to invest in safety equipment, and long-held beliefs and attitudes regarding safety in general. Considering the fact that more than half of the 4.8 million tractors in use on U.S. farms are not equipped with ROPS and that the average age of farm tractors in use today is 25.7 years, it is not surprising that the number of fatalities involving rollovers has remained high.

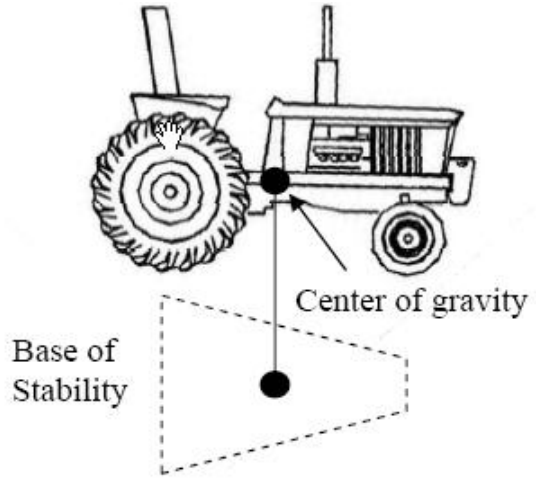
PHYSICS OF TRACTOR STABILITY

A tractor rollover event occurs when its *center of gravity* is displaced outside its *base of stability*. This holds true whether the tractor encounters a side rollover or rear rollover. As long as the tractor is operated such that the center of gravity remains within the base of stability, the tractor will not roll over.

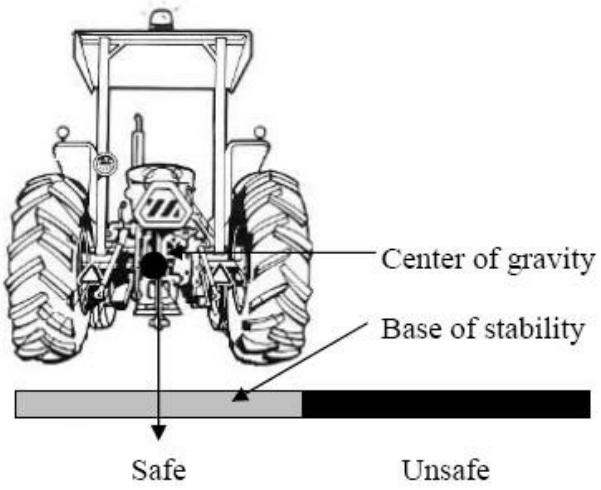


Center of gravity is defined as the point of equal weight distribution. This means that 50 percent of the tractor's weight is distributed in front of this point and 50 percent behind. This same principle applies from side to side and top to bottom. One any given tractor, the center of gravity will vary under different conditions.

Base of stability is defined as the area within the points where the tractor's wheels contact the ground. The base of stability depends upon the front- and rear-wheel spacing, and the axle-to-axle spacing.



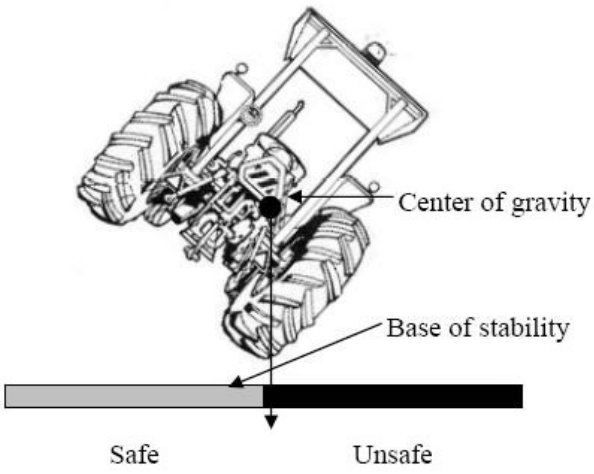
As long as the tractor is operated in a manner whereby the tractor's center of gravity is within the base of stability, the tractor is not subject to rollover.



However, circumstances that displace the tractor's center of gravity from within this safe zone will result in either a side or rear rollover incident.

SIDE ROLLOVERS

Approximately 85 percent of all tractor rollovers are side rollovers. Driving too close to an incline or embankment, driving too fast when negotiating a curve, driving the tractor with a loaded front-end loader in the raised position, uneven braking while traveling at high speeds, and losing control of the tractor due to excessive load on the drawbar are the major causes of side rollovers. Studies show that when tractor speed is doubled, the danger of rollover is increased four times.



Preventing Side Rollovers

Today, tractor manufacturers attempt to prevent side rollovers through design features and tractor options that widen the base of stability and lower the tractor's center of gravity. Some of these features include:

- Wide front-end design versus narrow or tricycle-type designs
- Adjustable rear wheel width and dual wheel tractors
- Wide tires
- Ability to lock brakes together
- Fixed drawbar height

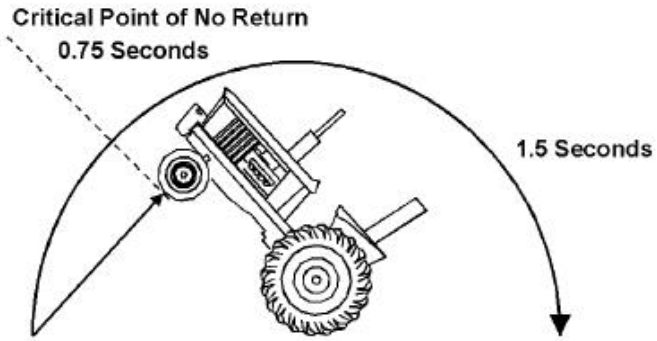
To reduce the potential of a side rollover, tractor operators should:

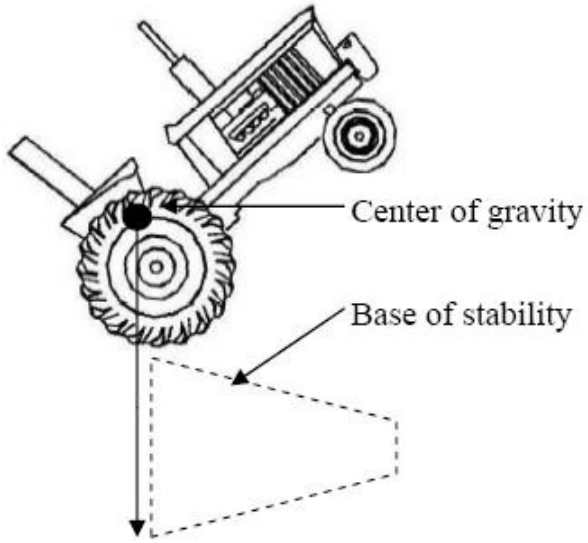
- Drive at appropriate speeds
- Set wheel tread as wide as possible
- Stay away from steep slopes, ditches, and embankments
- Keep front-end loader buckets low during transport or when turning
- Lock brakes together when traveling at high speeds
- Drive forward down steep slopes and back up them
- Slow down when pulling rear-mounted equipment

REAR ROLLOVERS

Rear rollovers are particularly dangerous because they happen so quickly. Operators have no time to react to avoid being injured or killed. Research of

rear rollovers show that it only takes 0.75 seconds to reach the critical point of no return (i.e., for the center of gravity to move over the rear axle and outside the base of stability.) From the time the tractor begins to rollover, the incident can take as little as 1.5 seconds.





Preventing Rear Rollovers

Tractor design features are available that reduce the risk of rear rollovers. Some features come standard on new tractors, while others are optional to be employed in specific circumstances to maintain proper weight balance. These include:

- Rear-wheel weights
- Tire ballasts
- Front-end weights
- Fixed drawbar height

To reduce the risk of a rear rollover, tractor operators should:

- Keep front-end loader buckets low when pulling rear mounted loads
- Add front-end weights when raising heavy rear mounted equipment
- Back up steep hills and driving forward down steep hills
- Hitch loads only to the drawbar and never hitch loads above the drawbar

Stuck in the Mud?

Rear rollovers may occur when operators attempt to free tractors that are stuck in the mud by placing items under the rear wheels to improve traction. Wheels stop slipping, rear torque causes the front end to rise off the ground, and the tractor's center of gravity moves beyond the rear axle. Always first try to back the tractor free. If that doesn't work, get another tractor to pull it out. Remember to attach the chain to the drawbar on the second tractor.

ROLLOVER PROTECTIVE STRUCTURES

Early attempt to reduce tractor overturn deaths in the U.S. during the 1950s resulted in the development of rollover protection structures (or ROPS). ROPS are protective frames securely attached to a tractor for the purpose of preventing the operator from being crushed if the tractor overturns. A seat belt is used to prevent the operator from being thrown from the protective zone. ROPS typically limit overturns to 90 degrees.

In 1976, the Occupational Safety and Health Administration (OSHA) passed regulation that all tractors built after October 25, 1976 and used by employees of a farm be equipped with ROPS. This regulation also requires that all employers ensure that seatbelts are used by the employees on ROPS-equipped tractors. Low-profile tractors used in orchards, greenhouses, and other buildings are exempted.

Legally, OSHA covers all farms with employees, even though OSHA cannot inspect farms with 10 or fewer employees. OSHA regulations do not apply if a farm operator uses his or her own labor or uses only family labor. About 90 percent of all farms are small farms with few or no employees. Thus, this regulation has limited impact for encouraging the use of ROPS on most farms.

A more significant development in the promotion of ROPS occurred in 1985, when the American Society of Agricultural Engineers (ASAE) revised an early ROPS standard to call for all new tractors to

have a ROPS. Subsequently, manufacturers now place ROPS on nearly all new tractors sold in the U.S., and make ROPS available as an option on models that are not fitted with ROPS at the factory.

Investigations of tractor rollover incidents show that more than 99 percent of injuries and fatalities occur with tractors that are not equipped with ROPS and when the tractor operator is not wearing a seatbelt. Despite the increased risk of injury, approximately 50 percent of the 4.7 million U.S. tractors in use today are not equipped with ROPS.

ROPS DESIGNS

Preventing tractor rollover injuries can be done in two ways: preventing the tractor from rolling over in the first place; and protecting the tractor operator in case of a rollover. In case of a rollover, there are several ROPS options currently available and in others still in the testing phase.

ROPS are commercially available in one of four designs: 1) part of an enclosed cab (cab frame serves as ROPS), 2) open-station four-post design, 3) open-station two-post design, and 4) foldable or manually adjustable (two-post ROPS that fold or telescope for low clearance). Research into alternative ROPS designs and automatic deployment is ongoing.

In 2003, the National Institute for Occupational Safety and Health (NIOSH) field-tested the prototype of a new Auto-ROPS design equipped with a sensor that detects when a tractor is tilting and deploys a rollover bar to a level higher than the operator's head. One objective of this design is to overcome the problems encountered in low clearance setting such as orchards, where a standard ROPS cannot be used.

NIOSH is also funding the development with FEMCO to produce different cost-effective ROPS (CROPS) designs. The goal is to make CROPS available for the most popular tractors currently without a ROPS.

ROPS RETROFITS

Many older model tractors without ROPS can be retrofitted with ROPS, however retrofits for some models may be difficult to find. The National Farm Medic Center, Marshfield Clinic, in Marshfield, Wisconsin has developed an on-line database of ROPS suppliers for many tractor makes and models.

http://www.marshfieldclinic.org/nfmc/rops/

The Guide to Agricultural Tractor Rollover Protective Structures (ROPS) lists sources for purchase of retrofit ROPS and tractors for which ROPS are available.

When retrofitting a tractor with a ROPS frame or ROPS cab, seat belts must also be installed; and on some instances, the seat may have to be replaced. Persons purchasing retrofit ROPS should ask the ROPS supplier about seat belts for the particular make and model of tractor. In some cases, the seat belt is provided with the ROPS package.

A ROPS must be installed correctly, according to the supplier's instructions. ROPS retrofits require specific hardware, and extra-strength bolts and fasteners. ROPS should never be modified by drilling, cutting, welding, or any other means as this may seriously weaken the ROPS structure and cause it to fail during an overturn.

HOMEMADE ROPS

The construction of homemade ROPS is strongly discouraged. Manufactured ROPS are specifically designed to conform to the tractor's load-bearing capacity, weight distribution, and strength of construction. Homemade ROPS are often made from inferior strength materials, are not attached properly to the tractor frame. These ROPS often fail during a rollover incident.

REFERENCES

Myers JR, Snyder KA. Rollover protective structure use and the cost of retrofitting tractors in the United States, 1993. J Agric Safety Health 1996;1:185-97.

National Institute of Occupational Safety and Health. National Agricultural Tractor Safety Initiative. January 2004.

United States Department of Agriculture. Bureau of Labor Statistics. Census of Fatal Occupational Injuries. 2002.

National Safety Council. Injury Facts.