



Braking Physics For Farmers

Examining the importance of braking systems on trailers.

**By Brad Stage
Fluid Power Specialist, MICO, Incorporated**

Many would agree that the “good old days” of farming are long gone. The business side of agriculture has changed, with family farms gradually disappearing and corporate farms becoming the norm. The way tasks are performed has also changed, as many farmers no longer have to eyeball their work while seeding, spraying, harvesting or cultivating. Instead, tractors are now equipped with GPS and other technologies that make farming a more efficient process.

Agriculture has screamed ahead into the future, yet a fundamental safety issue seems to have been left behind. With all the technological progress that’s been made, thousands of farmers are often still finding themselves in the precarious position of pulling a heavy trailer with an inadequate braking system or, in many cases, no brakes at all.

Generally speaking, the subject of trailer braking is only considered an issue when high speeds are involved, like in the case of a semi-tractor at risk of jackknifing while hauling a shipment down a highway. However, the potential for an accident exists anytime a tow-vehicle is not capable of resisting the inertia of a heavy trailer, regardless of the speed, the condition of the roadway, or other path of travel. Low speed tractors towing heavy grain carts or slurry tanks are susceptible to the forces that cause these accidents to occur. The accident potential is not just a highway concern.

Real Numbers on Real Dangers

Many farmers have adapted to the lack of trailer brakes by coming up with intuitive ways of stopping the trailer. One interesting alternative method for trailer “braking” is to just let off the clutch and slow down the tractor while the trailer sinks into the soil. In the case of an emergency stop situation, the operator simply drops the tractor bucket in the hope that the action brings everything to a halt.

MICO, Incorporated

1911 Lee Boulevard / North Mankato, MN U.S.A. 56003-2507

Web site: www.mico.com / **E-mail:** micomail@mico.com / **Tel:** +1 507 625 6426 / **Fax:** +1 507 625 3212



While many farmers can share stories where quick thinking saved the day, the statistics show that danger is not always avoidable. According to the National Institute for Occupational Safety and Health (NIOSH), tractor overturns cause 132 deaths each year. An analysis of NIOSH data between 1992 and 2005 indicates that 1,412 farm workers died of tractor overturns. Certainly there are numerous reasons for all of these overturns, but the focus of this article is to shed light on the importance of trailer braking systems in agricultural tractor towing applications.

Surely not every tractor-related accident or fatality will be avoided, no matter how many safety precautions are taken. Unfortunately, in too many cases farmers are not even aware that trailer braking is a significant safety issue worthy of their attention. What also must be addressed here is the importance of a Rollover Protective Structure (ROPS). While all rollovers may not be preventable, a ROPS system is shown to significantly improve the odds of survival for the operator.

Government Regulations

Part of what causes this lack of awareness is that a tractor, in the classic sense of the term, is not always thought of as a motor vehicle. More often it is perceived simply as a piece of machinery. However, once the “machinery” takes to a highway in the United States, a tractor is a motor vehicle subject to government regulations for safe travel. A trailer also obtains the distinction of being a motor vehicle by virtue of being attached to another motor vehicle — tractor or otherwise.

In the United States, any trailer with a gross vehicle weight rating of 3,000 pounds or more must have brakes that are adequate to control that trailer’s movement as well as provide for breakaway braking. The brakes must also be adequate to stop the trailer, hold it, and enable the driver of the towing vehicle to apply the brakes from the cab.

But, as with many rules, there is an exception to the basic guidelines on trailer braking. This exception applies to vehicles or implements of husbandry. The exception to the 3,000-pound rule applies to any vehicle used exclusively for agricultural purposes. These vehicles are not required to have brakes until different criteria are reached — and this secondary set of husbandry guidelines varies from state to state.



The key point in all of this is safety. Farm vehicles are typically slow moving and are allowed some exceptions not afforded other vehicle types, but when certain conditions exist, even agricultural trailers will need braking functionality to keep farmers and other roadway users safe.

Braking in Europe

A different set of standards for trailer braking exists in Europe, where farm tractor travel on highways tends to be much more common than in the U.S. Unlike the vehicles of husbandry exceptions in American guidelines, European regulations generally treat farm vehicles like any other vehicle. That being said, there are separate rules for various categories of tractor-trailers. These categories frequently cause a fair amount of confusion, so, as a general rule, some experts simply suggest that any trailers weighing more than five metric tons (11,000 pounds) when loaded should have service brakes, parking brakes and breakaway brakes.

Agricultural tractors in the U.K. cannot legally travel more than 20 mph unless fully suspended and equipped with an anti-lock brake system. However, in actual practice tractors not meeting those specifications routinely exceed that speed. As tractor speeds increase, the brakes on towed trailers become more and more inadequate even with the enhanced tractor braking requirements. This situation hasn't escaped the attention of European legislators, who are beginning to demand higher braking performance from tractors and trailers alike. Specifically, a new regulation in the UK requires 50% brake efficiency on all agricultural trailers manufactured in 2009 and forward, this is up from 25% in previous years.

Regulations notwithstanding, what simply cannot be overlooked is the negative effects of inadequate brakes on tractors or other towing vehicles. If a trailer braking system is insufficient for the weight and speed of the trailer, the tractor's brakes will be overloaded in an attempt to help make up the difference. This could lead to accelerated wear and eventually the failure of the tractor's braking system.

When Braking Happens

A look at the basic physics of the situation makes it pretty apparent how dangerous scenarios can arise when attempting to stop. Whether it's a pick-up truck pulling a boat or a tractor hauling a grain cart, most trailers pivot at a single point at the rear of the towing vehicle. Generally speaking, the



single hitch-point design makes a lot of sense, essentially providing a universal method for pulling trailers — as long as the towing vehicle is large enough, it can tow anything. This also allows trailers to be maneuvered with relative ease when making turns.

But for trailers without brakes, the single point alignment may allow too much freedom of movement when the towing vehicle is trying to stop. Think about pulling a child's wagon. Now think about turning around and trying to *push* that same wagon with the tongue and how difficult it would be to maneuver it. Chances are you would not keep the tongue completely straight, and may wind up with a jack-knife effect.

That's basically what's happening when a non-braking trailer pushes up against a braking tractor. As that pushing force is applied, the trailer's movement puts downward force on the pivot point where the tractor and trailer are connected. With enough pressure applied to a pivot point on the tractor's rear, the tractor's front wheels could be pushed up, creating the potential for a loss of control of both the tractor and trailer. In addition, the inertia of a heavy trailer behind a tractor can simply keep pushing straight, overcoming the tractor.

Managing the Physics

Without trailer brakes, the driver must control the amount of pressure that the trailer is applying to the tow-vehicle, thereby minimizing risk. The issue is that there are so many variables to this manual control method. Road conditions, moisture, tire pressure and even tiny gophers can create a close call, if not an actual rollover.

Braking requirements can be calculated by a formula that considers speed, mass, rolling radius and even surface conditions. Most of us are not capable of calculating this, so we react by feel and experience. But when you consider that speed exponentially increases the braking force needed, you simply have to understand that high speeds require much more braking force regardless of what the mass is of the complete towing unit.

By far the easiest and safest way farmers can control a trailer's stop is with appropriately sized trailer brakes. It's a simple concept, but one worth repeating — if a trailer is not equipped with brakes, its inertia will keep it moving faster than a tractor that is braking. By having the trailer brakes enabled at



the same time the tractor's brakes are applied, the trailer can match the speed of the tractor and they will slow down together. This eliminates the pushing effect from the trailer on the tractor and allows the trailer to maintain multiple friction contact points with the ground, rather than on its single pivot point with the towing vehicle.

Trailer Braking Methods

Farmers who use trailer brakes will have varying experiences, depending on the method of brake actuation being used. While the concept of slowing a tractor and trailer at the same time, and to the same speed, seems simple enough, there can be challenges in getting the two in sync.

For example, with electric brakes a vehicle driver can modulate the amount of electricity going to the trailer's braking system. With this method it is difficult to find a balance where the trailer and towing vehicle are each taking on their fair share of braking responsibility. The trailer may be doing the bulk of the pulling, or the tractor may do most of the braking. While the former is a little more preferable, it still wears down the trailer braking system more quickly than one would want and finding a balance often provides for a rather jerky affair.

There is movement from some tractor manufacturers to standardize trailer brake outputs via air. Air outputs are standard in Europe, and this method makes significant technical and economic sense. Among the advantages of using air brakes is that air is completely replaceable. If air leaks, the compressor can easily produce more. One important drawback with an air system, however, is the need to have large tanks and other components to actuate the disc brakes or drum brakes being utilized on the trailer. This significantly reduces the power-to-space ratio, increases trailer weight, and size limitations on trailers or axles could even prohibit the use of a large air system.

Hydraulic modulation is another possibility. For tractors with hydraulics, one common and basic method is to simply take a hydraulic feed off the tractor's standard two-line hydraulic system and push that directly to the trailer to actuate its hydraulic disc brakes.

If manufacturers do, in fact, adopt air output as standard, a tractor's hydraulic system could still do the trick using a hydraulic-to-air relay modulation valve. The valve works by sensing the incoming hydraulic pressure when an operator presses on the tractor's brakes. This pressure is then converted



to an air pressure outlet. This allows an air compressor system mounted on the tractor to modulate air pressure from the tractor to the trailer.

Just as a hydraulic signal can be converted to air, component manufacturers have developed actuation devices to convert an air signal to hydraulic in instances where hydraulic brakes may offer a better braking solution for a trailer.

It's About Safety

Farmers will encounter several situations where trailer brakes will not be a necessity. But to ensure the safety of everyone involved in a farming operation, it's important to have a healthy respect for the physics involved in bringing heavy machinery to a safe stop. Give careful thought to the situations a given piece of equipment will encounter to determine appropriate braking needs. Seek advice from the local implement dealer and find out what braking options are available. And do not forget to buckle your safety belt and use your ROPS system. The data is very clear that these safety precautions, when used in tandem, will help you stay alive in the case of a rollover.

No one is suggesting that the implementation of trailer brakes will guarantee the elimination of all tractor-related fatalities. But it's a step toward a safer work environment so that everyone, from the family farmer to the 60,000-acre corporate manager to the hired hand, will appreciate each and every day they get home safe and sound.

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