FAILSAFE BRAKES ON TRACTOR-DRAWN FARM TRAILERS

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ABSTRACT

Braking systems on tractor-drawn farm trailers can be operated either mechanically, hydraulically or pneumatically; however many trailers are not fitted with brakes at all, posing a serious risk. The South African Sugar Association Experiment Station undertook to build and test various systems by which efficient and inexpensive failsafe braking could be achieved for both moving and stationary situations. They are based on spring pressure to apply the brakes and hydraulic to release them. Several systems were built and tested for tractors equipped with both variable and fixed displacement pumps. The systems with merit are described.

Key words: Sugarcane, transport, trailers, brakes, design.

INTRODUCTION

The results of a survey (Anon'), showed that trailers were manufactured without brakes at the specific request of clients. This was rationalized in two ways: Firstly, on steep gradients the tractor driver would be forced to use the gears to slow down the tractor and trailer, otherwise he may drive downhill at a much higher speed using only the trailer brakes to slow down. This leaves no leeway for complete braking should an emergency situation develop. Secondly, the road conditions on flat country do not require more braking ability than that supplied by the tractor. If the tractor brakes are suddenly applied, there is the potential hazard of the trailer 'jack-knifing' against the tractor and possibly overturning.

Most trailer manufacturers fit brakes to their trailers as a matter of course. However, some would fit them only on request which is shortsighted because the cost of fitting brakes to a trailer is minimal when compared with the cost of repairs to expensive transport equipment damaged or injuries sustained in the event of an accident.

Pneumatic braking systems are well suited to the failsafe option and are used extensively on road transport trucks and trailers. However, due largely to the
high initial cost of the compressors and ancillary components, they are seldom fitted to general purpose farm tractors and trailers.

METHOD

Different failsafe systems were constructed for tractors fitted with either fixed or variable displacement hydraulic pumps and were bench tested using an hydraulic test rig. They were built to operate a pair of conventional 38 mm diameter single acting hydraulic cylinders which were mounted together with springs and retaining brackets, on a reconditioned heavy duty trailer axle of the type which is manufactured with lever actuated 'S' cam brake assemblies. To reach a suitable standard of braking efficiency, the criteria outlined in Appendix A was taken as the norm.

Following the satisfactory results obtained from the tests, the components used in the third system were fitted to a Ford 5610 tractor and a six ton basket trailer designed at the SASA Experiment Station and used for cane haulage on the Experiment Station La Mercy farm. The system was tested during the 1990/91 season. The only problem experienced to date has been a small leak in one of the brake cylinder seals.

Midway through the season it became necessary to fit the original brake and tip kit so that other trailers with conventional hydraulic systems could be used. The refitting necessitated the addition of a selector valve so that either the failsafe or the conventional brake and tip system could be selected.

RESULTS

System 1

Figure 1 shows the operation of a conventional brake and tip kit. When both conventional and failsafe systems of braking are used, this system is selected with a simple four port, two way directional valve. An open center spool valve is coupled between the pump output and the brake and tipping cylinders. By moving the spool lever in one direction, the brakes are applied by feeding oil to the brake cylinders through the ‘A’ port. Moving the spool lever in the other direction will pass oil via the ‘B’ port to the single acting tipping cylinder attached between the trailer chassis and deck. Releasing the lever to the neutral position will release the brakes or lower the trailer deck, depending on which has been selected.
System 2
The most simple failsafe system for tractors fitted with fixed displacement pumps is illustrated in Figure 2. Of prime consideration is the force of the brake shoes against the brake drums, which must be carefully matched to the hydraulic system pressure by choosing a cam actuating lever length suited to the diameter of the cylinders. Too little leverage will result in too little braking force and too much leverage may burst the brake drums.

![Diagram](image)

FIGURE 2. A simple failsafe breaking circuit.
A pool valve is coupled between the pump output and the brake line as in conventional brake and tip kits. By moving the spool lever in one direction oil is fed to the brake cylinders through the ‘A’ port. The ‘B’ port and tank ports are coupled and return the oil to the reservoir (tractor, gearbox). Pressure from the pump extends the cylinders releasing the brakes. When the lever is moved to the center position, oil from the pump is returned to tank and the ‘A’ and ‘B’ ports are blocked, holding the brake cylinders at system pressure. When the valve lever is moved the opposite way pressure is released from the brake cylinders back to the reservoir and the springs apply the brakes.
An advantage is that only one double acting tandem center spool valve is used to achieve failsafe braking. A disadvantage is that a small amount of oil will leak past the valve while it is held pressurized in the center position. This causes the cylinders to lose pressure after a few minutes and the brakes will apply gradually. It is advisable to mount a pressure gauge in a conspicuous place so that the driver will notice any drop in pressure and recharge the system before the brakes start binding and cause unnecessary wear to the brake linings.

System 3

System 3 (Figure 3) is essentially an accumulator charging circuit that uses an externally sourced pilot operated overcenter valve to maintain pressure in the brake circuit and at the same time return oil at low pressure to the reservoir.

![Fail safe braking circuit for tractor fitted with variable displacement pump](image)

**FIGURE 3.** Failsafe braking circuit for a tractor fitted with a variable displacement pump.

Initially oil at system pressure is fed directly to the cylinders through a check valve. An overcenter valve is coupled in reverse mode so that the integral check valve is disabled. The vent hole through the main spool is brazed shut and machined flush with the plug face. A slot must be cut in the main spool to allow oil trapped behind it to be evacuated.
The overcenter valve is teed into the high pressure side of the line before the check valve. The pilot line is coupled beyond the check valve, as is the line to the directional valve.

As the pilot line fills, pressure on the pilot spool in the overcenter valve increases until it overrides the spring pressure which normally holds the main spool closed. The two chambers are then opened and oil is vented to tank. Pressure beyond the check valve is held at the level to which the spring in the overcenter valve is set, normally 5 MPa. Pressure before the check valve drops to zero as the main spool opens, allowing oil to flow freely back to tank.

Depressing the pedal of the spring offset directional valve will open the spool, allow oil to flow back to tank and apply the brakes. Tension on the spring should be such that the foot pressure required to compress it is slightly less than or equal to the pressure required to apply the tractor brakes, so that progressive braking between the trailer and the tractor is achieved.

The advantage of this system is that it will automatically recharge if there is a drop in pressure in the brakeline. To prevent oil being lost in the event of a hose burst, pilot pressure is maintained by inserting another check valve (‘Q’ in Figure 3) between the pilot line and the directional valve junction in the main brake line so that oil at system pressure is maintained, thus holding the overcenter spool open to tank.

System 4

The operation of a system suited to tractors which are equipped with pressure compensated variable displacement pumps is illustrated in Figure 4. These pumps are designed to de-stroke at their maximum preset pressure and they therefore require a different type of valve with which to charge the brake cylinders and then de-stroke the pump by allowing the compensator to build up pressure.

The simplest hydraulic circuit (Figure 4) would consist of only an externally spool, pilot operated pressure regulating valve and a check valve and would be used in conjunction with the spring offset directional valve in System 3 which is mounted above the tractor brake pedals.

In the event of a hose burst the valve spool will be held closed by pilot pressure which is charged to a pressure determined by the preload on the adjustable spring (typically 5 MPa) and held there by the operation of the check valve, even though the pressure on the brake line side has dropped to zero by releasing oil through the fracture. Oil in the pilot line can only be released through the directional valve.
FIGURE 4. Brake release cylinders single acting.
CONCLUSIONS

The fitting of hydraulic-over-spring failsafe brakes to cane trailers is the only cost-effective solution that will ensure that the safety standards and legal requirements pertaining to braking systems are met. The hydraulic components used to construct the systems are commercially available and require no particular expertise to assemble. Finally, the inherent safety features ensure that a failsafe braking system is functioning and in good order, and that brake hoses are coupled, before the trailer can be moved. Any failure in the system will automatically apply the brakes.

REFERENCES


APPENDIX A

The criteria for constructing the failsafe braking systems described in this paper were based on the general specifications for brakes on category B and C trailers proposed by the South African Bureau of Standards (Anon²). The most pertinent facts are the following:

1. The trailer must be held stationary by a parking brake on slopes of up to 18%. In the case of failsafe brakes the automatic braking capabilities should meet this requirement.

2. The braking force applied by the driver using a supplementary power source (hydraulic) should bring the tractor and trailer to a standstill at the rate of less than 2.4 m/sec (Anon²), i.e. tractor and laden trailer travelling at speed must stop within a distance according to the formula:

$$D = 0.208 \times U^2$$

where, $D =$ distance in m, and $U =$ speed in m/sec.
DES FREINS DE SÉCURITÉ POSITIVE POUR LES REMORQUES DES TRACTEURS

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RESUME

Les systèmes de freinage sur les remorques des tracteurs peuvent être actionnés d’une façon mécanique ou hydraulique ou pneumatique; cependant plusieurs remorques ne sont par munies de freins posant ainsi un risque très sérieux. La South African Sugar Association Experiment Station entreprit de fabriquer et de tester plusieurs systèmes de freinage à sécurité positive et peu coûteux, et efficace sous condition mobile ou en stationnement. Ils sont basés sur un système à ressort pour appliquer les freins et à pression hydraulique pour les relâcher. Plusieurs systèmes furent fabriqués et testés pour des tracteurs munis de pompes volumé-triques fixes ou variables. Les systèmes méritants sont décrits.

Mots clés: Canne à sucre, transport, remorques, freins, dessin.

LOS FRENOS SEGUROS PARA SEMI-REMOQUES TIRADOS POR TRACTOR

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RUSUMEN

Los frenos para semi-remolques tirados por tractores pueden operar por sistemas mecánicos, hidráulico o de aire. No obstante, algunos semi-remolques trabajan sin frenos lo que representa un gran riesgo operacional. La Estación Experimental de la Asociación Azucarera de Africa del Sur, se adjudicó la tarea de construir y evaluar varios sistemas por los cuales se pudiera equipar la unidad de transporte con frenos seguros, eficientes y económicos, y así poder operar en situaciones móviles y estacionarias. Estan basados en la aplicación de presión mediante muelles al frenar, y presión hidráulica al soltarlos. Varios sistemas fueron construidos y probados para operar con tractores provistos con bombas de desplazamiento fijas y variables. Se describen los mejores sistemas.

Palabras claves: Caña de azúcar, transporte, semi-remolque, frenos, diseño.