LOOK BEHIND YOU!

A Guide to Tractor-Trailer Braking

Contents

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1. Introduction

What would make you think about trailer brakes? Tractor not stopping as it should? Worries about expensive tractor brake repairs? Or the fear of an accident: a potential hefty fine or, far worse, a tragic loss of life? The reason doesn't really matter – the important thing is that you should think – and you **should** read this guide.

Ten years ago, the first 'Look Behind You' booklet highlighted the problem of premature tractor brake failure. The cause? Often inadequate trailer brakes. Older trailers, designed for use at slower speeds, were being towed by newer, faster tractors with expensive and potentially-dangerous results. Poor trailer braking system maintenance was also a factor. The original booklet summarised legal requirements and highlighted trailer braking system features which could reduce the problem, and to a large extent it was successful.

Much has changed in the last decade. Tractors, trailers and trailed implements are bigger; more tractors can now reach 50 km/h (30 mph) and pneumatic (air) trailer braking systems are more common. Certain UK Legislation has changed and new EU Braking Regulations for agricultural vehicles have arrived.

Although tractor-trailer braking in the UK has improved, more still needs to be done - so the AEA Service Managers' Group has revised the 'Look Behind You' guide. It still covers the basics, but also highlights things which have changed or which need more attention from you - the owner or user!

Watch the introductory video here

image courtesy thecourier.co.uk

2. Definitions – What do we mean by...?

Technical terms can sometimes be interpreted differently. The following terms appear regularly in this Guide - this is what we mean by them.

Braking System

Everything on a vehicle which operates when the brakes are applied: from the control (e.g. foot pedal) to the brakes themselves and everything in between

Service Braking System

Braking system used to control, slow down and stop a moving vehicle

Parking Braking System

Braking system which holds a vehicle stationary once stopped, even on a slope, and continues to work when the driver is absent

Dual-Line (braking system)

In a tractor-trailer context, this enables the driver to apply the trailer brakes and bring the vehicle combination safely to a stop, either if the tractor's brakes or engine fails, or if a trailer brake hose disconnects/fails (N.B. The trailer's brakes may apply automatically)

Failsafe (braking system)

Automatically applies the trailer's brakes if the trailer and towing vehicle (tractor) separate

Load Sensing

System which automatically adjusts a vehicle's maximum braking effort/force depending on the weight/load being carried (e.g. unladen/part-laden/fully laden)

Braking Effort

The total force(s) generated by a braking system to slow down or stop a vehicle and/or keep it stationary

Braking Efficiency

A measure of a vehicle's 'braking power' (see page 5)

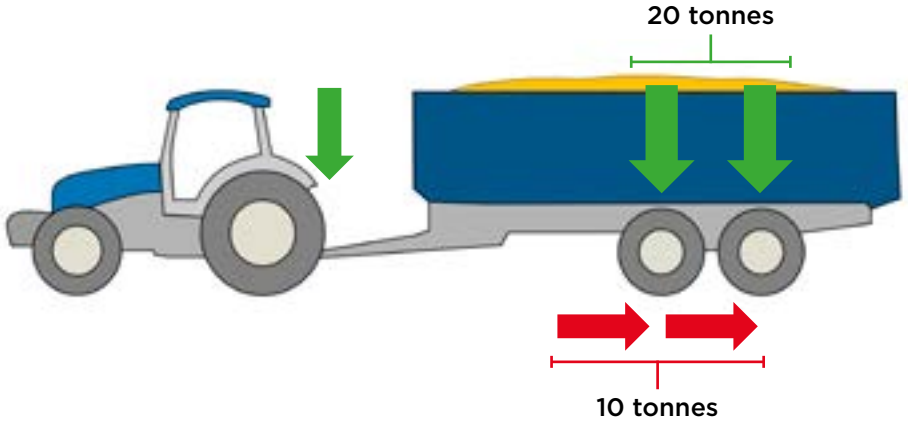
Trailer or trailed implement? Virtually all comments made in this guide regarding agricultural trailer braking also apply to trailed implements (or 'agricultural trailed appliances'). However, there are some differences in legal requirements, so do check out Section 5.

Braking Efficiency

Brakes try to prevent the wheels from turning and so generate braking forces which slow the vehicle (red arrows in Fig. 1)

But if the trailer is heavier, the brakes have to work harder as they have to generate more braking force to slow it down at the same rate as before.

Fig.1 Forces which act on a trailer during braking



Important: Different vehicles may be lighter or heavier, but if each one can develop the same **Braking Efficiency**, they will each slow down and stop at the same rate. This is why road vehicle regulations use braking efficiency to specify braking system performance levels.

So how is braking efficiency calculated?

$$\text{Braking Efficiency (\%)} = \frac{\text{Vehicle Braking Force}}{\text{Vehicle Weight}} \times 100$$

So in Fig.1:

$$\text{Trailer Braking Efficiency} = \frac{\text{10 tonnes (red arrows)}}{\text{20 tonnes (green arrows)}} \times 100 = 50\%$$

One other thing: Notice how the trailer braking efficiency calculation only uses the weight carried by the vehicle's wheels? (e.g. 20 tonnes in Fig.1) But many trailers also transfer a vertical load onto the tractor via the drawbar. This increases the tractor's weight and adds to its own braking load. So when towing a trailer, the tractor's brakes have to work harder than when travelling solo, even if the trailer's brakes are working perfectly!

3. What's Required from a Tractor-Trailer Braking System?

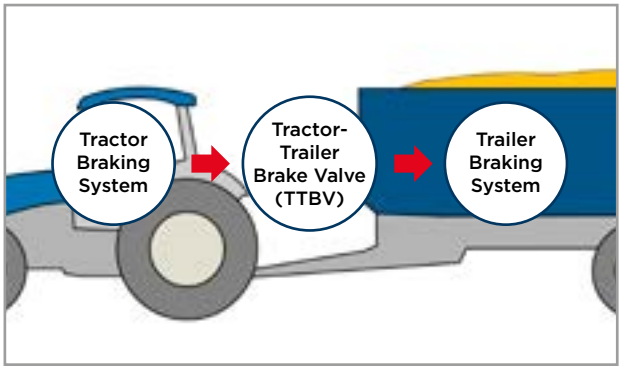


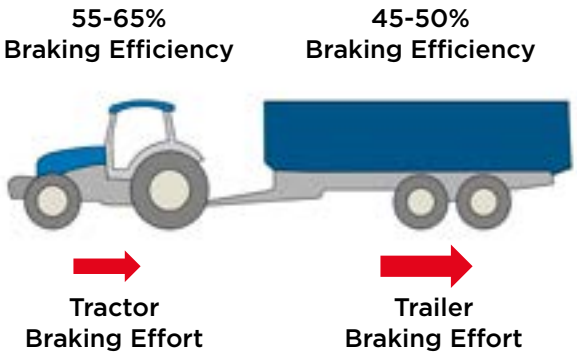
Fig.2 Role of the tractor-trailer brake valve (TTBV)

Watch the video

During braking the tractor and trailer must work together as the two are linked by the trailer drawbar. So for stability and safety, the separate tractor and trailer braking systems must respond as one and decelerate each vehicle at the same rate. To achieve this, the braking efforts produced by each system are co-ordinated by the Tractor-Trailer Brake Valve (TTBV) (see Fig.2)

Co-ordinated and matched tractor and trailer braking may seem logical, but it doesn't always work out that way in practice (see Fig.3)

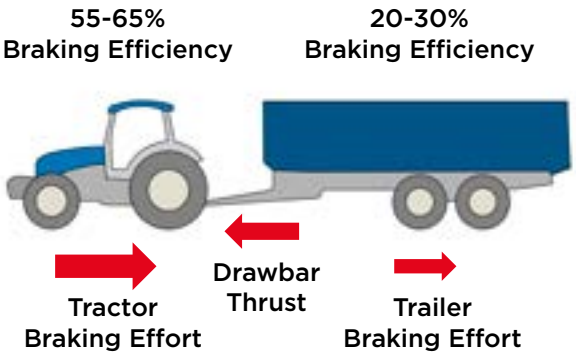
Fig.3 Alternative tractor-trailer braking scenarios



The Ideal Scenario

Braking effort is balanced between the tractor and trailer (they have similar Braking Efficiencies)

- Braking is distributed in proportion to the loads carried by the axles
- When laden the trailer must generate more braking effort than the tractor (because its axles carry more weight)
- When unladen the trailer must generate less braking effort



The More Common Scenario

The trailer generates insufficient braking effort (has a lower braking efficiency than the tractor)

- The tractor brakes have to make up the shortfall (causes overloading & excessive brake wear)
- Trailer pushes the tractor during braking, increasing the risk of jack-knifing
- Trailer doesn't adjust its max. braking effort from laden ▸ unladen (poor or no Load Sensing) Causes over-braking, excessive tyre wear and possible instability during unladen braking

System Requirements - Summary

The tractor and trailer should each generate sufficient braking force to decelerate the load carried by their own wheels. To do this, **trailer braking** efficiency must equal (or be similar to) **tractor braking** efficiency. Otherwise the trailer will push the tractor during braking.

Unfortunately, even though many trailer braking systems have improved, their 20-40% braking efficiency rarely matches the 55-65% achieved by modern tractors. So every time the brake pedal is used, the tractor's brakes take more of the load than they should - which leads to overloading and possible early failure.

System Requirements

A good trailer braking system has three essential characteristics:

Capacity

Axle brakes which are large enough to deliver adequate braking performance without excessive wear. Braking Efficiency should match that of the tractor (approx. 50%)

Control

System automatically adjusts braking effort to match the load carried (unladen ▸ part-laden ▸ fully laden)

Speed of Response

Trailer brakes should apply fully within 0.6 secs of pressing the tractor's brake pedal

4. The Different Effects of Speed and Weight

If a vehicle travels faster or is heavier, you'd expect the braking system will have to work harder to stop the vehicle. But does a little extra weight or a bit more speed have the same effect? Surprisingly, no! **Speed has a much greater effect** (see Fig.4).

Increasing a tractor-trailer combination's weight by 50% (e.g. from 20 tonnes ▸ 30 tonnes) while travelling at the same speed, causes braking system load to increase by 50% or 1½ times. But if the tractor and trailer stayed at the initial weight, yet travelled 50% faster (e.g. 20 mph ▸ 30 mph), braking load would increase by 125% - that's 2¼ times the initial braking load. So travel speed is much more important.

A trailer cannot influence the speed at which it is towed: that's up to the tractor up front and its driver. Many trailers and their braking systems were never designed to exceed 32 km/h (20 mph), but today they are towed by tractors which can travel much faster. For safety and reliability, it's vital that both tractor and trailer braking systems have the ability to work effectively at today's road speeds.

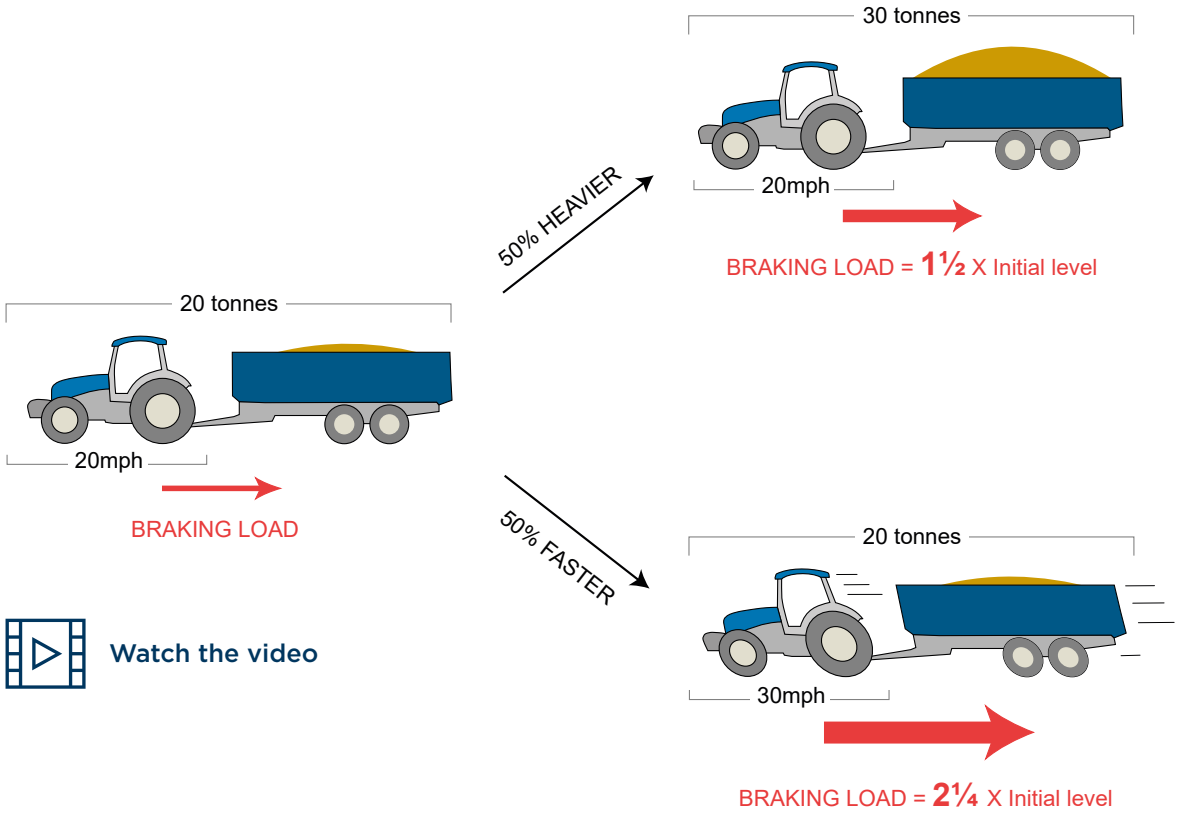


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Fig.4 Effect of increasing vehicle weight or speed on braking system load

5. Braking Legislation and Regulations

Road legislation may not be very interesting, but understanding and abiding by the rules may avoid a hefty fine - or even worse.

This guide focusses on tractor and trailer braking system requirements and other recent changes. However, it is worth noting these important, overall requirements:

- All owners and users of vehicles driven on UK public roads have a legal responsibility to maintain their vehicles in a safe and roadworthy condition at all times. This is a fundamental requirement, even though MoT-type testing does not apply to agricultural vehicles – not yet
- Whether on-road or off-road, the Provision and Use of Work Equipment Regulations (1998) (PUWER) require that any equipment used for work must be suitable for the task and be properly maintained and guarded. Also, adequate training must be provided to all users and information about the equipment made available

Watch the video

Bottom Line? Whether it's used on-road or only off-road, a vehicle and its safety-critical braking system **must** be properly maintained and **must perform**. In law there is simply no excuse for anything less.

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5.1 – Current UK Agricultural Vehicle Braking Legislation

Agricultural vehicles used on UK roads must comply with the requirements of the Road Vehicles (Construction and Use) Regulations 1986 - as amended. Better known as C&U Regs, as the name suggests, these specify legal requirements for road vehicle design/construction and also their operation/use.

Braking requirements for agricultural tractors, trailers and trailed implements (e.g. balers, sprayers) vary slightly. New tractors sold in the UK must comply with EU braking regulations, which in many ways are more demanding than C&U Regs (see Section 5.2). Trailers and trailed implements sold in the UK need not comply with EU requirements: instead they must satisfy the (often more lenient) C&U Regs.

C&U Regs effectively split braking system design and performance requirements for agricultural vehicles into two speed-related categories. If used above a given threshold speed, more stringent (truck & bus) requirements apply. For nearly 30 years the speed threshold was 20 mph, but in 2015 it was raised to 40 km/h (25 mph), but only for tractors and trailers. Despite this quite large shift in speed, the technical requirements have not changed. **Table 1 highlights the main points.**

Table 1 - UK Braking Requirements for Agricultural Trailers – a summary

Up to 40 km/h	Above 40 km/h
Less demanding requirements apply: • Trailer service braking system must generate at least 25% braking efficiency when fully laden • Service braking system must act on at least half the wheels / axles • Single-line hydraulic or pneumatic (air) brake actuation is acceptable, but if trailer gross weight exceeds 14230 kg the service brakes must be operated directly from the tractor's service braking system • Parking brake must act on at least half the wheels / axles, and stop them from rotating when applied	**Commercial vehicle requirements apply:** • Trailer service braking system must generate at least 45% braking efficiency when fully laden • Service braking system **must** be both Dual-line **and** Failsafe, but not necessarily pneumatic. - The driver must be able to apply the trailer brakes if any part of the towing vehicle's braking system fails – Unless they apply automatically - The trailer brakes should automatically apply if the tractor and trailer accidentally separate whilst in motion • Service braking system must incorporate automatic wear adjustment* • ABS (anti-lock) brakes must be fitted* • Parking brake must hold the fully laden, uncoupled trailer stationary on a 16% slope

* Information supplied by the Department for Transport - March 2020

Bottom Line? If travelling faster than 40 km/h, UK law requires nearly twice as much trailer braking performance, plus extra backup safety features. Also, regardless of maximum speed, there is a legal requirement to adjust and maintain braking systems in good and efficient working order.

5.1 – When is a Trailed Implement ..... a Trailer?

Braking legislation recognises that the sole purpose of a trailer is to transport a load. Trailed implements work mainly in the field, cover fewer road miles and therefore perhaps don't need the braking capability of a trailer. **BUT** some trailed implements travel on the road both when laden and unladen (e.g. loader wagons, slurry tankers, sprayers); and some large, modern implements can weigh more than a laden trailer. C&U Regs currently deals with trailed implement braking system requirements like this:

A trailed implement does not require brakes if:

- It is not towed above 20 mph, **and**
- Its gross weight is less than double its unladen weight, **and**
- Its maximum gross weight does not exceed 14,230 kg

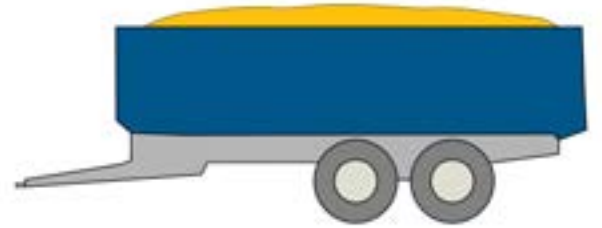
A trailed implement must meet trailer braking requirements if:

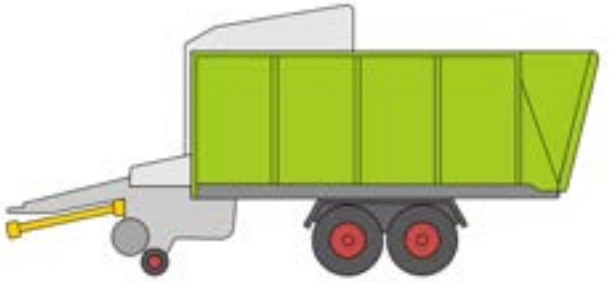
- It is towed at speeds up to and including 20 mph, **and**
- Its gross weight equals or exceeds double its unladen weight, **or**
- Its maximum gross weight exceeds 14,230 kg

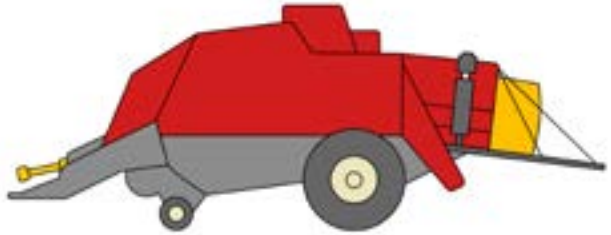
BUT:

- Irrespective of its maximum gross weight, if towed at speeds above 20 mph, a trailed implement must be fitted with a commercial vehicle / high-speed trailer spec. braking system* (see Table 1, right column)

* Information supplied by the Department for Transport - March 2020







Bottom Line? So there are few practical cases where a trailed implement does not legally require brakes and some instances where UK legal requirements are actually more demanding than for a trailer.

5.1 – How Heavy can it be?

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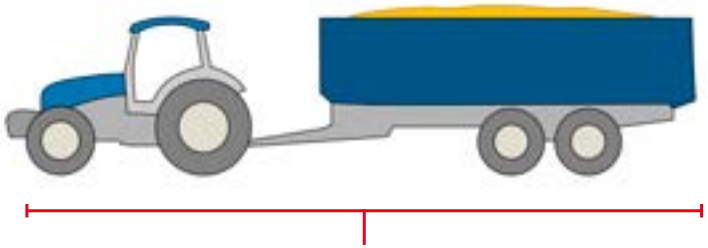
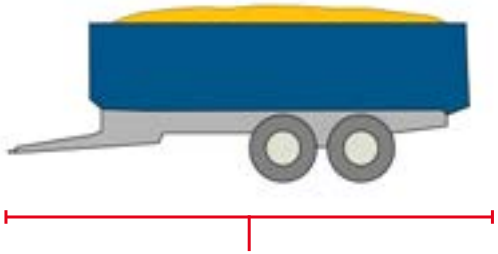
C&U Regs also specify maximum operating weights for both trailers and tractor-trailer combinations. In 2015 the tractor-trailer maximum gross weight limit was raised to 31 tonnes, from approx. 24 tonnes. This allowed existing agricultural trailers to be towed by larger, heavier tractors without reducing their potential payload.

However, the trailer maximum gross weight limit **was not increased**. So the 18.29 tonnes value set in 1986 still restricts the payload of modern agricultural trailers used on UK roads to approx. 13.5 tonnes, depending on trailer unladen weight. Given that the most common grain trailer size sold in the UK is currently 16 tonnes, it appears that this legal restriction is often being ignored.



Tractor + Trailer Max Gross Weight = 31 tonnes



Agricultural Trailer Max Gross Weight = 18.29 tonnes

Fig.5 Revised UK agricultural tractor and trailer weight limits

5.1 – Fast Tractor Roadworthiness Testing

From May 2018, Periodic Roadworthiness Inspection & Testing (MoT testing) became a UK legal requirement for 'faster' tractors (those with a maximum speed capability above 40 km/h)

However, this only applies to these tractors if they:

- Are used for commercial haulage purposes (i.e. are required to use white diesel and are not eligible to be taxed as an agricultural vehicle), **and**
- Haul goods more than 15 miles from their operating base (which is not necessarily where they are registered)

Eligible vehicles must be tested at an HGV testing facility when four years old, and then every two years.

Important

Any tractor used solely for agriculture, horticulture or forestry purposes is exempt from these requirements, even if it can exceed 40 km/h **BUT:**

- Tractors which can exceed 40 km/h by design, but which are electronically limited to 40 km/h (e.g. have a 40k 'Eco' travel mode), may still fall within the requirements, depending on their use
- If a tractor used for 'commercial haulage' purposes tows a trailer, this cannot be regarded as an agricultural trailer. So it must meet all the requirements of a road-going 'haulage' trailer, including approval before first use and subsequent annual roadworthiness inspection/testing.

5.2 – EU Agricultural Vehicle Braking Regulations (RVBR)

The RVBR regulations provide a long-overdue overhaul of agricultural vehicle braking requirements. As far as the UK is concerned, at the time of writing, RVBR requirements only apply to new tractors sold since January 2018.

- **Tractors** - Braking systems of new vehicles must meet RVBR requirements when first placed on the market (registered for use), as must the tractor–trailer brake control valve (TTBV) systems. RVBR compliance must be independently verified by vehicle approval authorities, before sale
- **Trailers and Trailed Implements** - Manufacturers can choose to meet RVBR requirements, or instead can satisfy the generally less demanding UK C&U Regs. Unlike the RVBR, C&U Regs do not require independent system performance checking & approval before sale.

Bottom Line? Trailer and trailed implement manufacturers recognise that this variable, country-specific approach for braking requirements has its drawbacks: it's much easier to build machines to one specification. Consequently the EU's RVBR rules **may** be imposed on all agricultural trailers and trailed implements sold in the future. The UK may or may not choose to adopt this approach.

Watch the video

6.1 – Single-Line Hydraulic

A simple system, used in the UK since the 1970s. The main features include:

- Simultaneous control of tractor and trailer brakes from the tractor brake pedal
- A tractor-trailer brake valve (TTBV) which sends hydraulic pressure to the trailer, where hydraulic rams apply the brakes
- Trailer braking effort depends on system supply/control pressure provided by the tractor
- Trailer braking system response depends on the TTBV's characteristics, plus trailer brake ram size and brake hose diameter
- The system is neither 'Dual-line' nor 'Failsafe'. That is, the trailer's brakes won't operate if:
  - Tractor hydraulic power is lost or a hose fails
  - The tractor and trailer separate

Important

Single-line hydraulic braking is therefore **NOT** legal for use on UK roads above 40 km/h

Bottom Line? Single-line hydraulic braking is now outdated and no longer accepted on new trailers in many EU countries. It can be fitted to new tractors sold in the EU until end-2024, but only if installed alongside Dual-line pneumatic or Dual-line hydraulic systems (see Sections 6.2 and 6.3). It is still fitted to new UK trailers, but usually alongside other braking systems, to provide backward compatibility with older tractors. As yet there are no signs that the UK intends to restrict the sale of Single-line hydraulic trailer braking systems in the future.

6.2 – Dual-Line Hydraulic

A new system introduced by the EU RVBR regulations (see Section 5.2). It has Dual-line and Failsafe features and therefore can be used above 40 km/h in the UK.

Key points are:

- Similar to a Dual-line pneumatic braking system: it must achieve the same system response time
- Applying the tractor's Parking brake also applies the trailer's Service brakes

Dual-line hydraulic systems are most likely to be found on post-2017, small to medium-sized tractors and telehandlers. As yet they are not fitted to trailers or trailed implements in the UK.

The tractor/towing vehicle has two hydraulic couplings (see Figs 6 and 7)

- A large 'Control' line coupling
- A smaller 'Supplementary' line coupling
  - An ABS-type electrical connector may also be required, to warn the driver of trailer braking system malfunctions (e.g. low 'Failsafe' accumulator pressure)
- Single-line hydraulic braking systems on existing trailers and trailed implements can be connected to the large Control line coupling on Dual-line systems

Bottom Line keypoints - see page 17

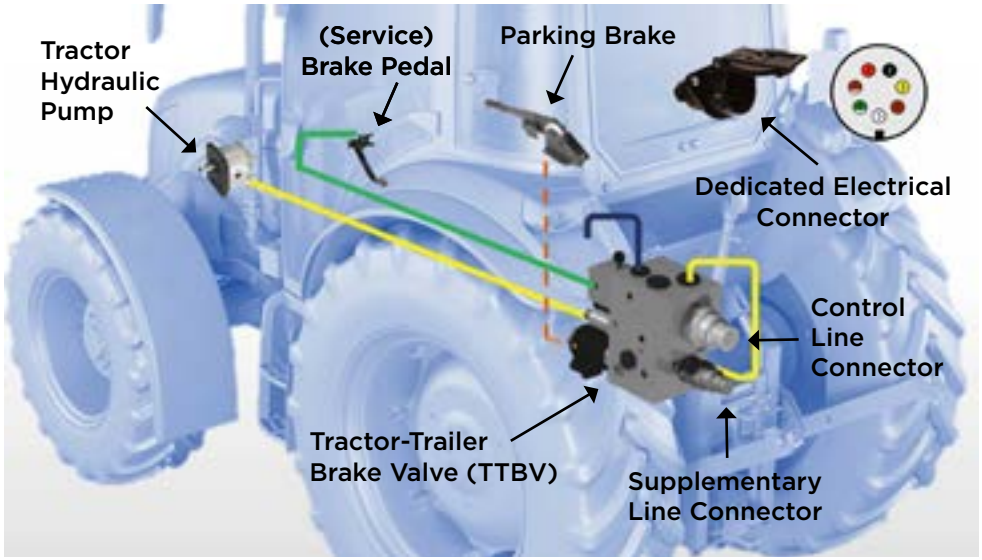


Fig.6 Dual-line hydraulic trailer braking system – Tractor installation (Paul Forrer)

Fig.7 Dual-line hydraulic trailer braking system couplings on tractor

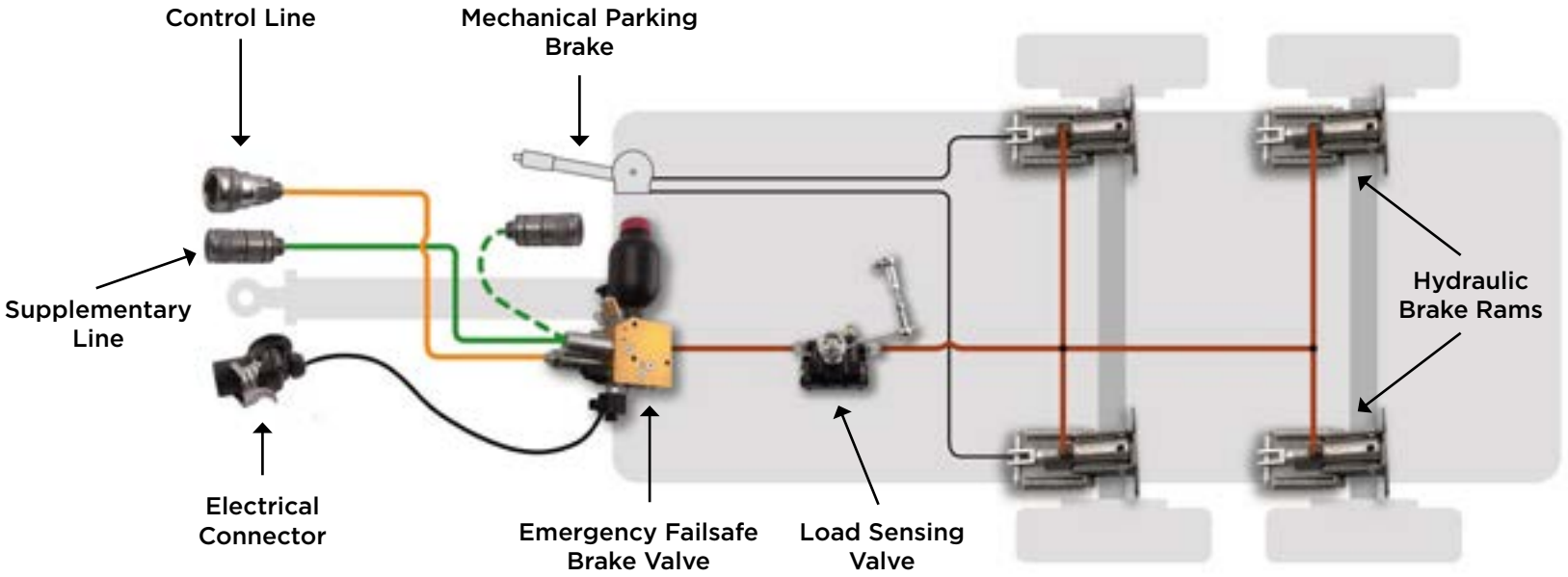


Fig.8 Dual-line hydraulic trailer braking system – Schematic layout (Paul Forrer)

Bottom Line? UK legislation may not mandate the use of Dual-line hydraulic systems in the future, **BUT** C&U Regs **already** require tractor-trailer braking systems used above 40 km/h to be Dual-line **and** Failsafe (see Table 1). Manufacturers can choose to fit either pneumatic or hydraulic dual-line systems, but the overall system performance requirements remain the same for either type.

6.3 – Dual-Line Pneumatic (Air)

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Pneumatic (air) braking systems are now much more popular and are probably the most common braking system used on larger tractor-trailer combinations. UK take-up has been helped by widespread fitment of trailer air brake equipment on newer, larger tractors

Air braking systems used on UK agricultural trailers are:

- Pressure-applied by single-acting pneumatic actuators (air chambers), **BUT** unlike truck systems, there is no spring-applied Parking Brake
- 'Dual-line' and 'Failsafe' in operation – so are suitable for use at speeds above 40 km/h
- Responsive .... although control is ultimately down to the tractor's trailer brake valve (TTBV)
- Often fitted alongside Single-line hydraulic brakes (see Section 6.1), so the trailer can also be towed by older tractors without an air brake system

Remember that in most cases, the air braking equipment on the tractor is just there to power and control the trailer's brakes – not the tractor's.

6.3 – Dual-Line Air - How does it work?

A trailer's Dual-line air brake system works like an electrical relay circuit; i.e. a separate signal is used to control the power supplied by the main circuit (see Fig.9)

- The Red 'Supply' (or Emergency) line just supplies air pressure to the trailer's reservoir
- The Yellow 'Control' (or Service) line carries an air pressure 'signal' from the tractor's TTBV to the trailer-mounted Relay-Emergency Valve
- The Relay-Emergency Valve applies or releases the brakes depending on the Yellow line's 'signal', using pressure from the trailer's reservoir, **BUT:**

  - If reservoir pressure is low, there will be poor (or no!) trailer brakes. The Red 'Supply' line must always be connected, to continually recharge the reservoir

- The Shunt or Manoeuvring valve (if fitted – see Fig.10) can temporarily release the brakes of an unhitched trailer so it may be moved around the yard, if an air brake-equipped tractor isn't available. Without a Shunt valve, the trailer's air reservoir must be drained.

Fig.9 Typical Dual-line pneumatic (air) braking system for an agricultural trailer (TractAir)

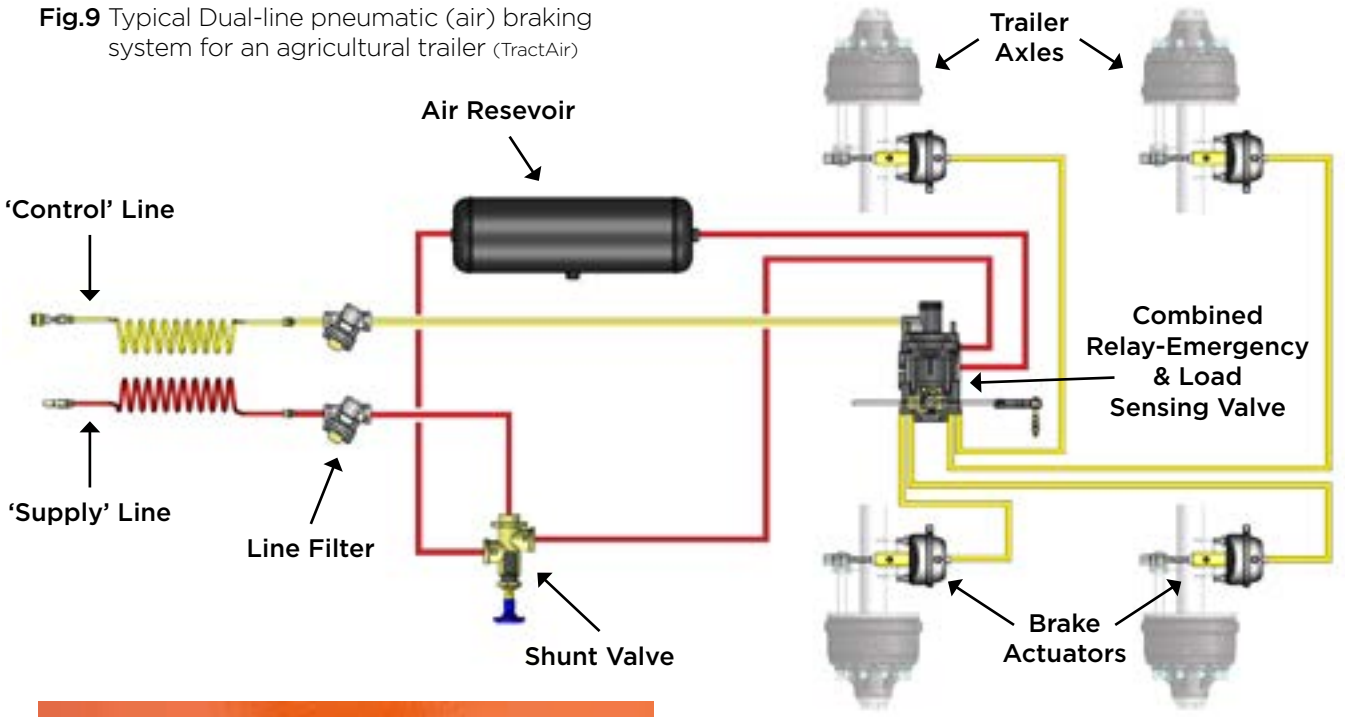


Fig.10 Shunt valve fitted to an air-braked trailer

6.3 – Dual-Line Air - Safety Features and Important Do's and Don'ts

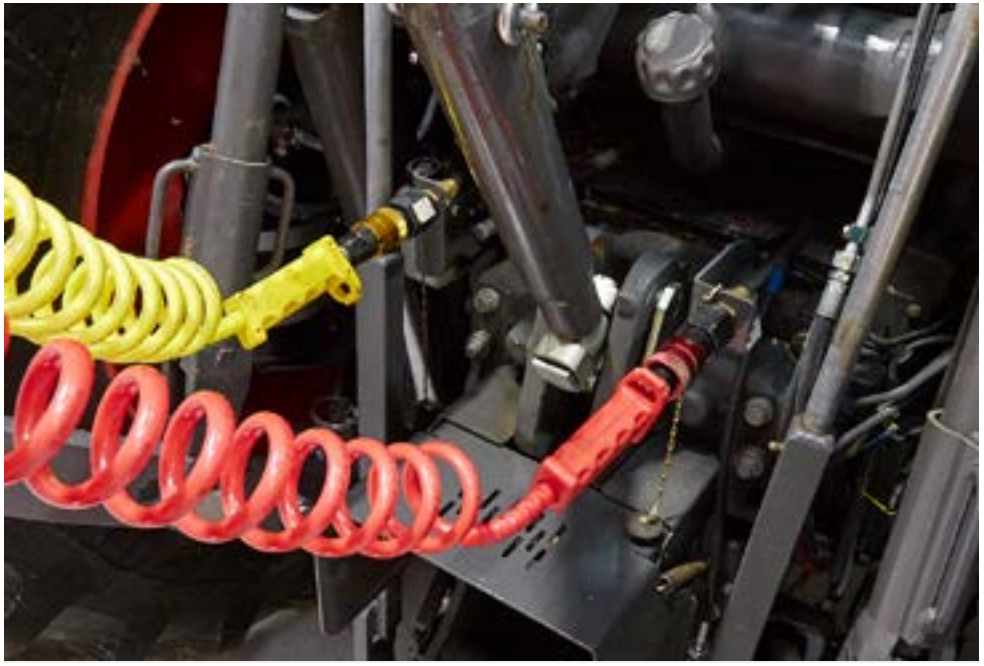


Fig.11 Dual-line trailer air brake system coupled to tractor

Safety Features

- If the Red 'Supply' line breaks or disconnects (and there is pressure in the trailer reservoir), the Relay-Emergency valve will apply the trailer brakes automatically (i.e. Failsafe operation). **Always check this happens whenever the trailer is unhitched from the tractor**
- If the tractor's braking system fails (or the engine stalls), the driver can still apply the trailer brakes using the tractor's Secondary brake control (either the foot brake, the Parking brake or an Emergency brake control)

Important Do's and Don'ts

- When coupling/uncoupling, to keep the trailer brakes applied for as long as possible, **ALWAYS disconnect the Red line first** (before the Yellow line) and re-connect it last.
- **ALWAYS** apply the mechanical Parking Brake. Don't rely on trailer air reservoir pressure to keep the brakes of an unhitched trailer applied
- **NEVER** connect both hydraulic **and** air brakes at the same time. Use either one system **OR** the other
- **ALWAYS** ensure the Shunt valve releases when the air brakes are next connected: otherwise the trailer's reservoir won't refill and you will have no trailer brakes!

Bottom Line? Dual-line air brakes are far superior to Single-line hydraulic systems, but they can't work miracles. If either:

- The trailer's brakes are undersized or in poor condition (see Section 7),

or

- Brake actuator travel is excessive (poor brake adjustment – see Section 8)

Your trailer braking system **will NOT perform** .... air brakes or no air brakes!

7. Trailer Axles and Brakes

With a 40 or 50 km/h tractor up-front, it's vital that a trailer's braking system can cope with both speed and weight-imposed loads and still be durable and reliable in-service. Selecting the correct 'foundation' brake type and size is a crucial first step

What is the Foundation Brake?

The brake drum and shoes form the 'foundation' of the trailer's braking system. Brake capacity depends both on drum diameter and shoe width. Higher load capacity axles and/or those used at higher speeds are fitted with larger foundation brakes (see Fig.12). Make the wrong choice for your intended speed and maximum load and it could prove to be costly.

Watch the video

What is an 'Ag. Spec' brake?

Ag. spec (agricultural specification) brakes are fitted to lower capacity axles and so are usually smaller (e.g. Ø300 x 60 mm or Ø400 x 80 mm – see Fig.13). Importantly they use 'flat'-type operating cams which don't provide very progressive brake control, making them unsuited to use above 40 km/h. They are likely to be fitted to smaller trailers, older designs or trailed implements.

What is a 'High Speed' or 'Commercial' brake?

'Commercial' foundation brakes generally use larger drums and shoes (e.g. Ø406 x 120 mm or Ø420 x 180 mm – see Figs 12 & 14) to handle higher braking loads. However, their most important feature is an 'S'-shape operating cam which gives more progressive brake control. The sheer size of the drum indicates how these brakes can dissipate the heat produced during higher-speed braking. Depending on the size of air chamber or brake ram fitted, commercial axles/brakes will enable the trailer to achieve 50% braking efficiency when fully laden – an ideal match for a modern tractor.

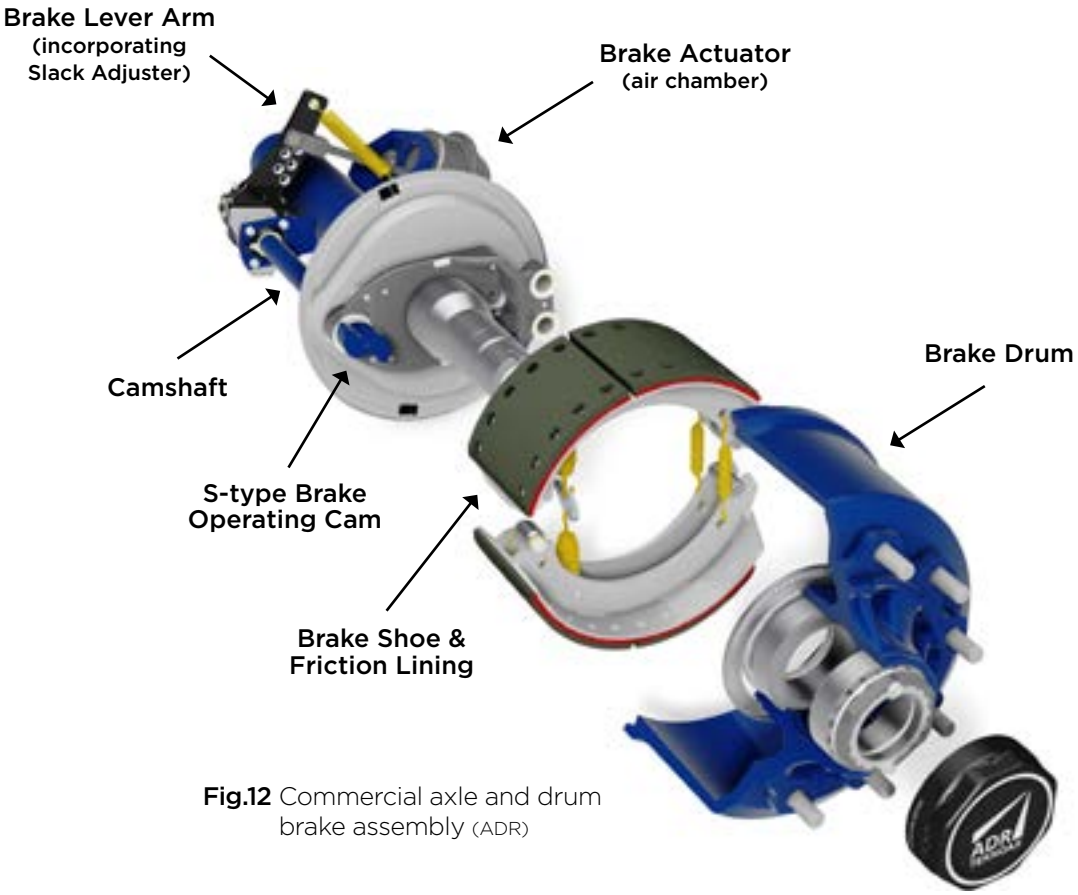


Fig.12 Commercial axle and drum brake assembly (ADR)

Can the Foundation Brakes be too big?

Yes, they can! Here's the balance to strike:

TOO SMALL

Brakes will deliver insufficient braking effort and (if used at higher speeds) will overheat and wear-out prematurely

CORRECT SIZE

Brakes will generate the required braking effort and also last much longer. Importantly, they will get hot enough in use to minimise 'glazing' (see below)

TOO BIG

Brakes will be difficult to control and won't generate enough heat during use, causing the friction linings to 'glaze'. This limits the braking effort which can be produced, making the vehicle act as if it were fitted with smaller brakes. Big brakes, but no performance!

Bottom Line? It is very important to select the right brake size/capacity for the speed and weight of the vehicle ... but remember, speed has a much greater influence (see Section 4)

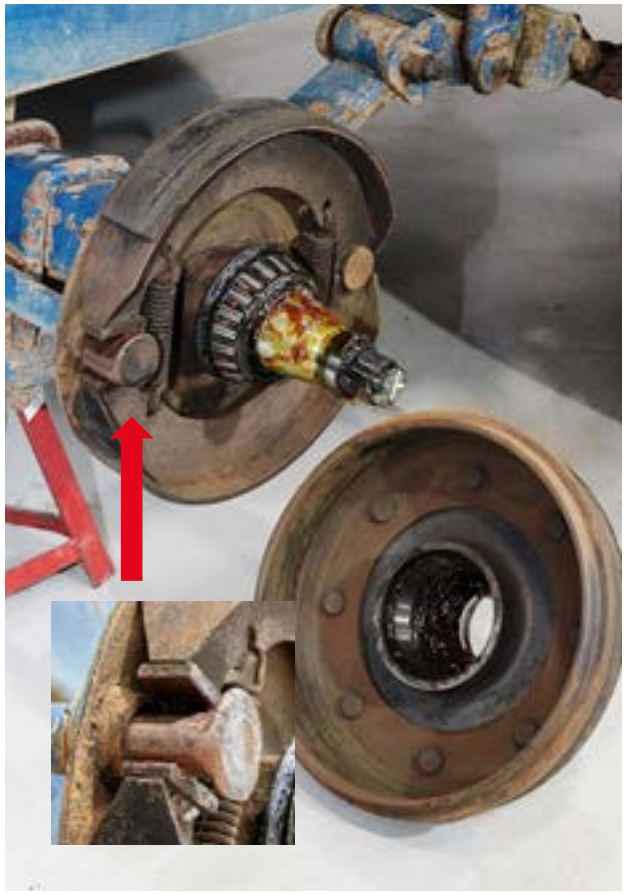


Fig.13 Example Ag. Spec brake and drum – Note 'Flat'-type operating cam (arrowed & inset)

Fig.14 Example Commercial 'High-Speed' brake and drum- Note 'S'-type operating cam (arrowed & inset)

8. Brakes – Putting them on

Having bought a trailer with decent-sized brakes and axles, to suit the likely payload and your tractor's maximum speed, surely all your problems are solved? Not necessarily. Unless the brake actuators (the air chambers or hydraulic rams) can produce enough force to apply the brakes firmly, braking performance will be below par.

Watch the video

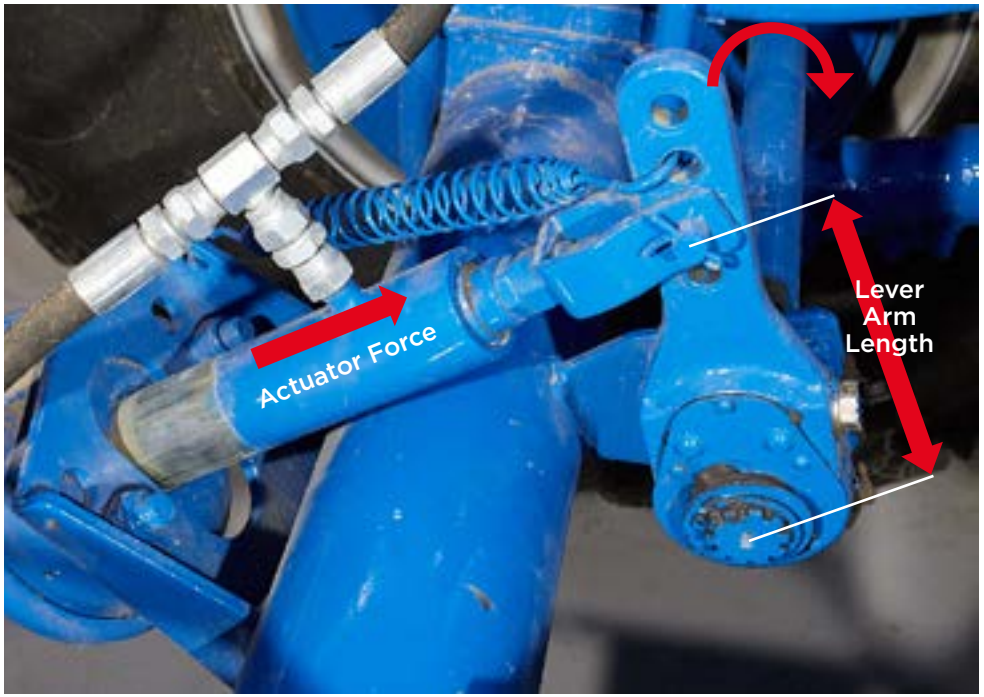


Fig.15 Trailer drum brake operated by a Dual-Supply (combined hydraulic and pneumatic) brake actuator

Brake Actuator Specification

Other things being equal, braking performance depends on brake size and application force. Trailer brake air chambers and hydraulic actuating rams come in a range of diameters: larger versions produce more force at a given input pressure (see Fig.16). In operation the actuator pushes the brake lever arm, which rotates the camshaft and applies the brake (see Fig.15). Alternative holes in the lever arm allow the actuator to generate higher or lower levels of camshaft torque. Trailer manufacturers select foundation brake size, brake actuator size and lever arm length to produce sufficient braking effort to suit a trailer's intended operating speed and gross weight. If you operate heavier or faster, the braking effort will be too low and the braking system will be overloaded.

Do you get the same Braking Performance from Hydraulic or Air?

Perhaps, but more probably not! Newer trailers are often fitted with 'dual-supply' actuators: these combine a hydraulic ram and air chamber in a single, compact unit (see Fig.15). But braking effort depends on the operating torque delivered to the brake. Less Input Torque ▸ Less Braking.

Trailer manufacturers know that Single-line hydraulic brakes should not be used at speeds above 40 km/h and will usually place a suitable warning sticker on the trailer headboard. However, due to the UK's speed-related braking requirements (see Section 5.1), the capabilities of the braking systems fitted to the same trailer may be different.

Sometimes, when both pneumatic and hydraulic braking systems are fitted, the air brakes may be sized to deliver the approx. 50% braking efficiency required for travel above 40 km/h, but the hydraulic rams may be selected to just achieve the baseline 25% braking efficiency required for slower-speed use (i.e. below 40 km/h). This is entirely acceptable under C&U Regulations, but it has two very undesirable side effects:-

- The trailer will perform quite differently depending on whether the air or hydraulic brakes are used
- The brake linings will tend to glaze when the hydraulic system is used, further reducing braking performance ..... even when next using the air system

Bottom Line keypoints - see page 24

Bottom Line?

- **Beware** – the same trailer with the same foundation brakes may have different braking performance depending upon which brake actuation system is used
- **How can you tell?** - Unless Load Sensing Valves are fitted to **both** the hydraulic **and** the air braking systems (see Section 9), the chances are the hydraulic system will have lower performance than the air system
- **REMEMBER - If both Hydraulic and Air brakes are fitted to a trailer, NEVER connect both at the same time**

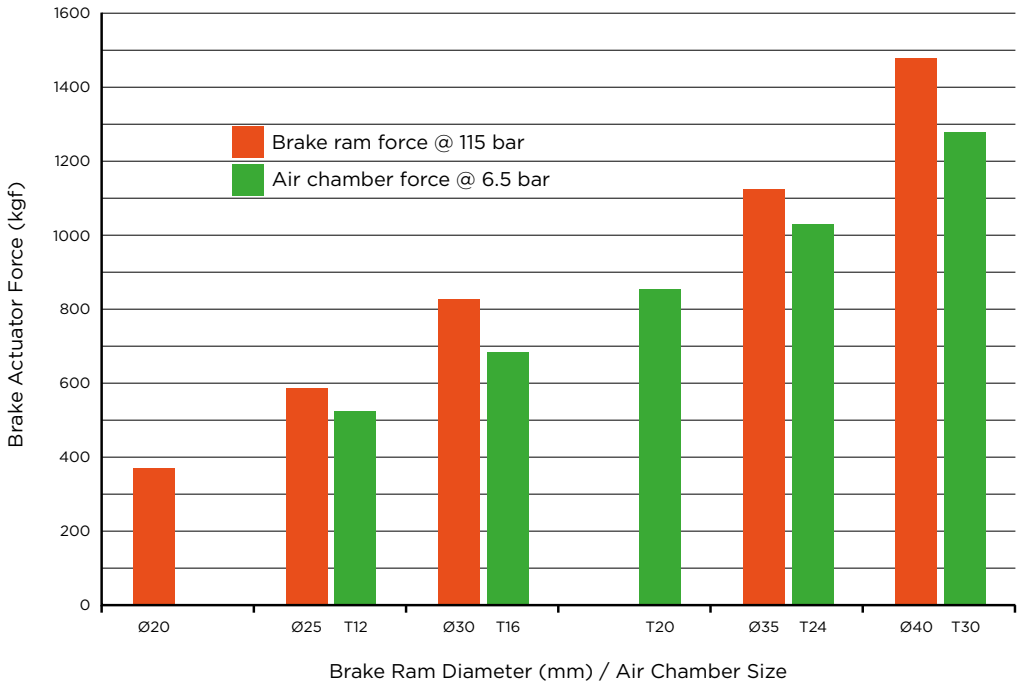


Fig.16 Effect of brake ram or air chamber size on brake actuation force

Brake Actuator (Free) Travel Adjustment

It's **extremely important** to check and (if necessary) adjust actuator free travel regularly, to compensate for brake lining wear.
Why does it matter? Because:

- Brake actuators usually have approx. 75 mm available stroke. As brake linings wear, the actuator must extend further to apply the brakes, so increasing its free travel. **If this is allowed to reach the approx. 75 mm limit of stroke, the brakes will no longer be applied!** (see Fig.17)
- Actuator force is converted into brake camshaft torque most effectively when the actuator operates (with brakes applied) at 90° to the lever arm. So if the brakes aren't adjusted, actuator free travel increases and braking power is reduced (see Fig.18)
- **REMEMBER** - Trailer brake response time increases with greater actuator travel as it takes longer for the brakes to be applied. This leaves the tractor carrying more of the braking load until trailer's brakes 'wake-up'

Very Important Bottom Line

ALWAYS adjust brake free travel if the actuators have to extend by more than two-thirds of their maximum stroke (i.e. more than 50 mm) to apply the brakes. Adjustment is made via the slack adjuster or by re-positioning the brake lever arm on the camshaft (see Figs 19 & 20)

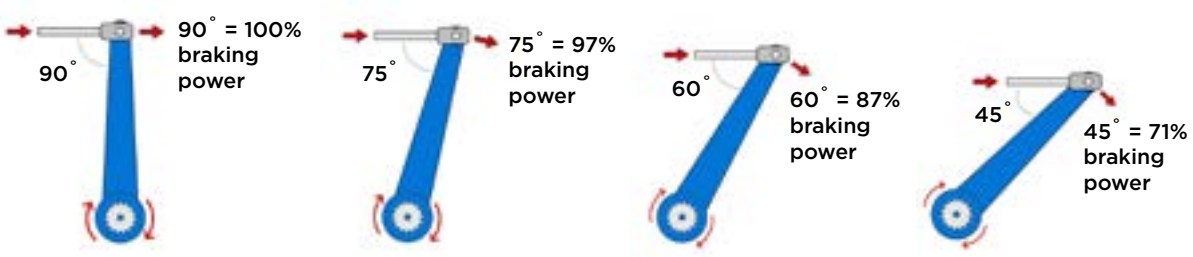


Fig.18 Effect of brake actuator/lever arm angle on braking power (Erentek)

Fig.17 Excessive brake actuator free travel = No Brakes!

Fig.19

Brake lever arm incorporating manual screw-type slack adjuster – Quick & easy to adjust free travel

Fig.20

Simple, splined brake lever arm – Must be removed from camshaft to adjust brake actuator free travel

Manual screw-type slack adjusters (see Fig.19) make free travel adjustment quick and easy. Old-style splined lever arms (see Fig.20) are difficult to adjust and should be replaced with screw adjusters.

Automatic Slack Adjusters

The Service braking systems of trailers used above 40 km/h (and trailed implements used above 20 mph) must incorporate means of automatic adjustment to compensate for friction lining wear (see Table 1). This is usually achieved by fitting brake lever arms which incorporate automatic slack adjusters (see Fig. 21). 'Autoslacks' are screw-type slack adjusters which include a mechanism to rotate the adjusting screw, should brake free travel become excessive. These are well-proven, reliable components, but they are not 'fit-and-forget'. They still require regular inspection to ensure their adjustment mechanism is working correctly.

Fig.21

Brakes lever arm incorporating automatic slack adjuster
(Granning)

Hydraulic Brake Hose Diameter

Trailer air brakes tend to respond rapidly whereas, to apply the brakes, Single-line hydraulic systems have to push a cold column of oil right back to the axles. If ¼" bore brake hoses are used, they will restrict oil flow and so increase brake response time, especially if larger rams are fitted to get more braking effort. Replacing a trailer's hydraulic brake hoses with larger ½" bore main feed and ⅜" bore ram supply hoses will improve brake response times considerably – especially on cold days!

8. Brakes – Putting them on - cont.

Too Much Braking?

Leaving tyre marks on the road? Well-matched foundation brakes and actuators can deliver that desirable 50% trailer braking efficiency required to stop a fully laden trailer. However, unless told otherwise, the system will generate the same braking effort during unladen braking, even though the vehicle may weigh 70% less! The result is over-braking, wheel locking, excessive tyre wear and possibly trailer instability. Fortunately, this problem can be solved by an effective Load Sensing system (see Section 9) - an essential feature of higher-performance trailer braking systems.

What about ABS?

Antilock Braking Systems (ABS) are a UK legal requirement on trailers used above 40 km/h and trailed implements used above 20 mph (see Table 1). EU braking regulations are less demanding and only require ABS to be fitted if the trailer or trailed implement is intended for use above 60 km/h.

ABS is designed to maximise braking performance, prevent skidding and maintain steering control when braking on slippery surfaces. Some consider ABS to be a substitute for Load Sensing on trailers, but it is not. ABS can complement a trailer's Load Sensing system and further-refine braking performance, but it is not a solution on its own.

9. Load Sensing – Do you need it?

Watch the video




Does your trailer/trailed implement have a good braking system?
- More than 35% braking efficiency?

Y → Does its axle load(s) change significantly in use (Laden ▸ Unladen)?
e.g. a trailer, loader wagon, trailed sprayer, slurry tanker, muck spreader

Y → Does it travel on-road both when Laden and Unladen?

Y → **You DEFINITELY need a Load Sensing System**

N → **You Don't Need a Load Sensing System**

N → **You Don't Need a Load Sensing System**

N → **A Load Sensing System would be beneficial**

Bottom Line?

In these applications, effective load sensing will be **essential** to prevent over-braking, wheel locking and excessive tyre wear during unladen braking.

9. Load Sensing – What does it do?

Load Sensing tells the trailer's braking system how much weight/payload the trailer is carrying. When unladen or part-laden, it reduces trailer braking effort to match the reduced axle load, **BUT** the trailer still develops the **same Braking Efficiency** as when fully laden – which will then match that of the tractor (see Fig.22)

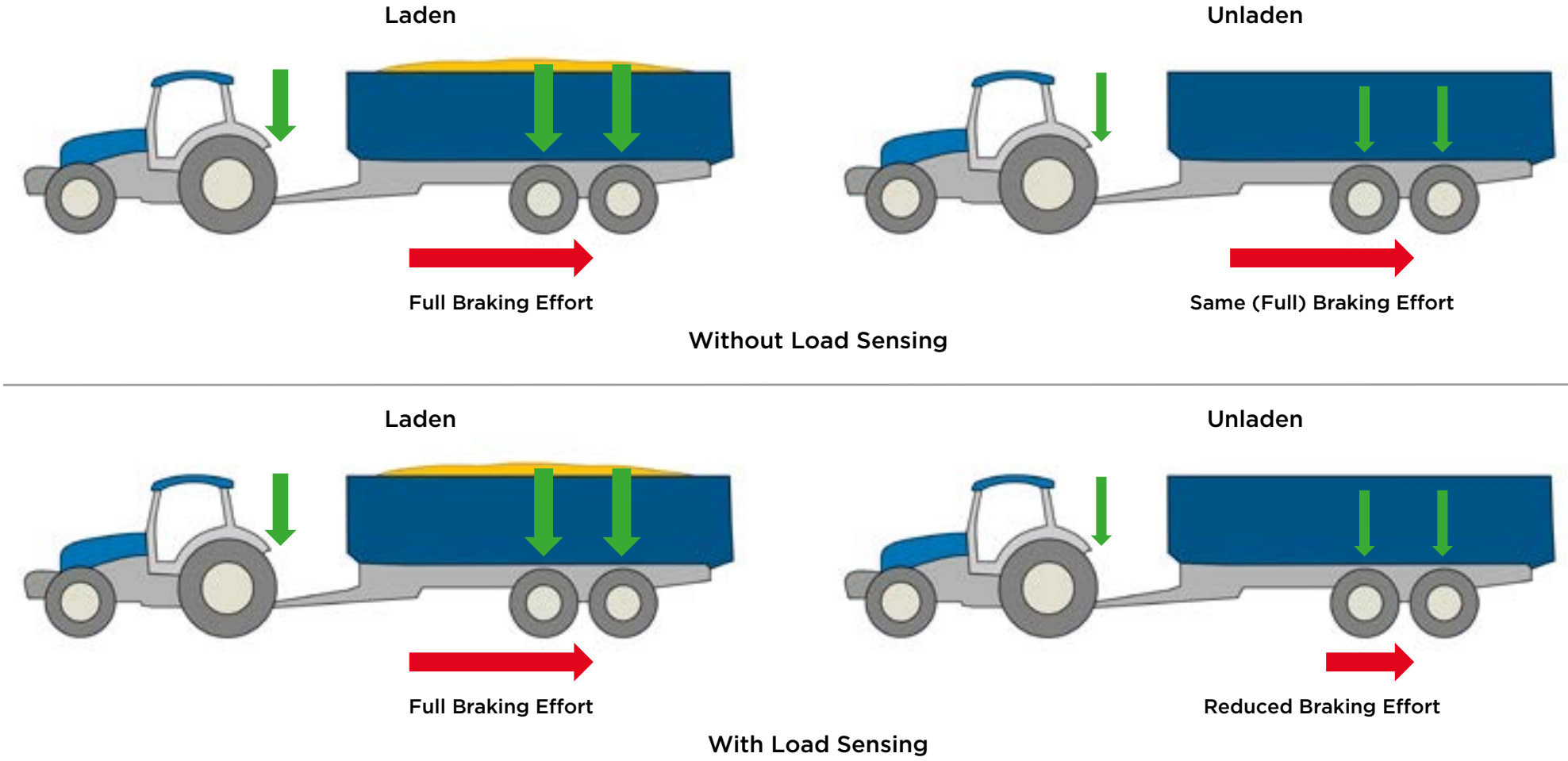


Fig.22 Trailer braking with and without Load Sensing

9. Load Sensing – How does it work?

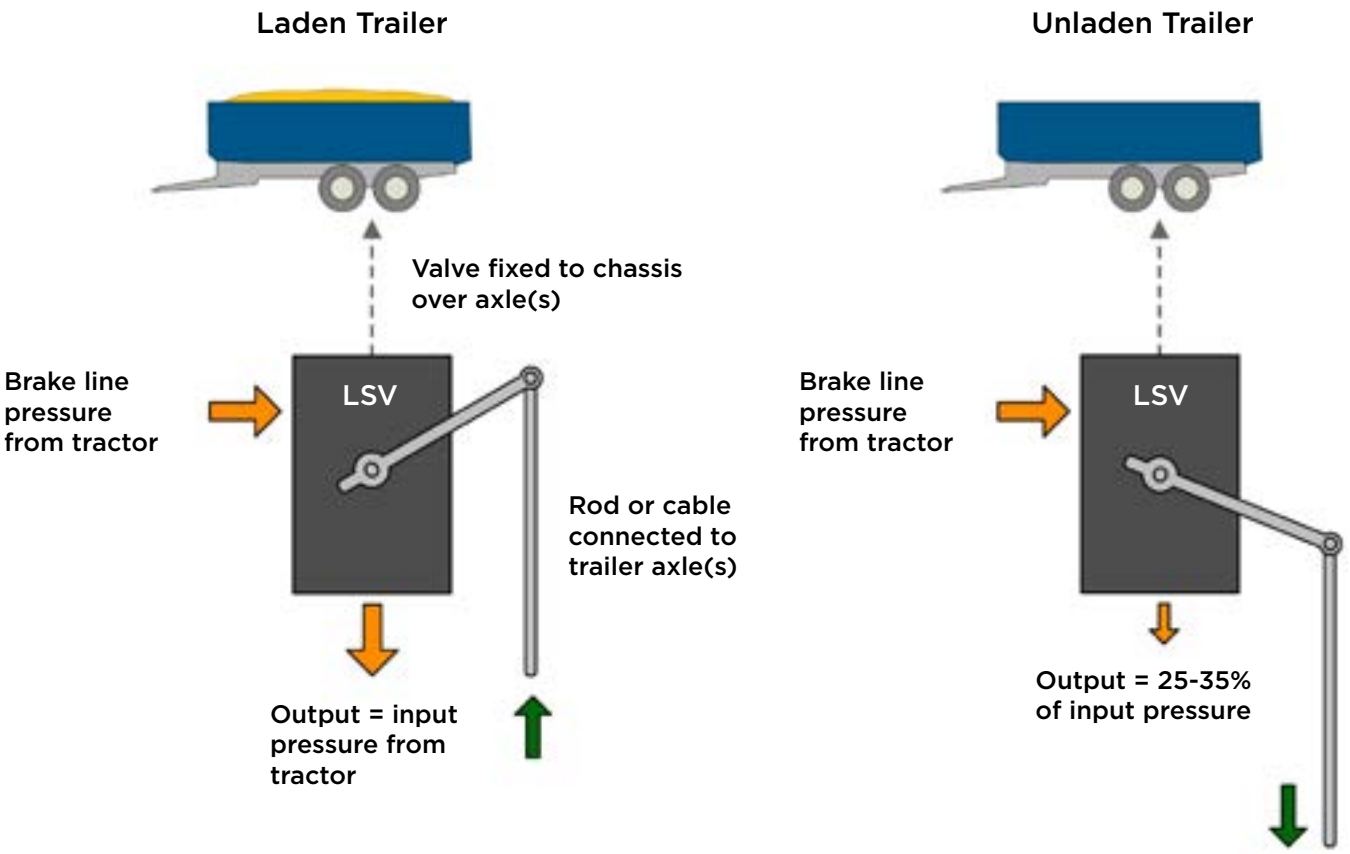


Fig.23 Load Sensing Valve (LSV) operation

- The Load Sensing Valve (LSV) automatically adjusts trailer brake line pressure
- Changing trailer payload (unladen ▸ laden ▸ unladen) causes the suspension springs to deflect. This movement operates the chassis-mounted LSV via a linkage or cable
- When unladen or part-laden, the LSV reduces the pressure passed to the brake actuators (see Fig.23). This reduces braking effort in line with the smaller payload, so the trailer still develops the **same braking efficiency as when fully laden**
- If set correctly, LSVs can eliminate over-braking, wheel locking and excessive tyre wear during unladen & part-laden braking and improve vehicle stability.
- LSVs can be fitted to both pneumatic (air) or hydraulic trailer braking systems (see Fig.24)

Fig.24 Hydraulic (above) and Pneumatic (right) trailer Load Sensing Valves

Load Sensing Valves – Limitations

Trailer Load Sensing Valves are well-proven and generally reliable components, but they can't work miracles. Common problems include:-

- **Stiff Suspension:** Stiff/strong trailer springs may seem like a good idea, but they limit laden ▸ unladen suspension travel, which in turn limits LSV accuracy and overall performance
- **No Suspension:** If the trailer axles are not spring-suspended (e.g. rocking beams), a LSV cannot be installed. LSVs are sometimes fitted to drawbar suspensions, but stiff drawbar springs and variable loading during normal operation makes this solution a really bad idea
- **Incorrect LSV Setup:** Every time the trailer suspension moves, so does the LSV. It will develop wear over time and its settings may drift … so have it checked over (see page 32)

9. Load Sensing Valve Operation – Should you check it?

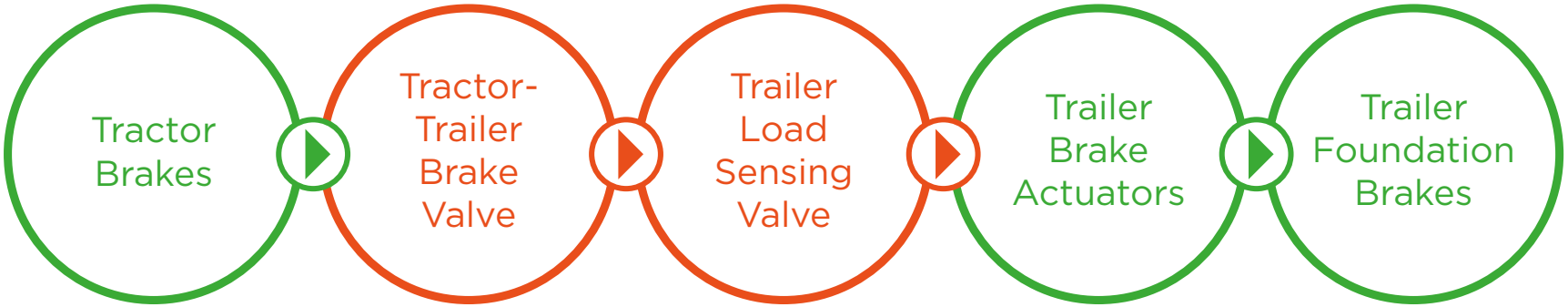


Fig.25 Tractor-trailer braking – the Chain of Command

The Load Sensing Valve (LSV) varies the pressure delivered to the trailer brake actuators during braking, and so it controls the braking effort produced. That makes the LSV a **critical component** which has **significant control** over trailer braking performance (see Fig.25). It **MUST** be set-up correctly and operate effectively, otherwise the trailer braking system will not perform properly. This could be both dangerous and illegal.

Setting-up (and Checking) Load Sensing Valves

LSV installation and setup depends on the valve's characteristics and also the particular trailer's own:

- Axle loads when it's laden and unladen
- Suspension travel – from laden ▸ unladen
- Braking system specification/capability

LSV setup and adjustment should be left to a specialist: a dealer or the vehicle manufacturer, ideally someone with brake performance measuring equipment. That said, it is still a very good idea to **check** the LSV is working properly.

9. Load Sensing Valve Operation – Checks can be performed easily

Correct LSV operation can be checked by using two accurate pressure gauges to measure the LSV Input and Output Pressures when the trailer brakes are applied. This should be done when the vehicle is fully laden (e.g. brim-full of grain) and then be repeated when unladen (see Fig.26).

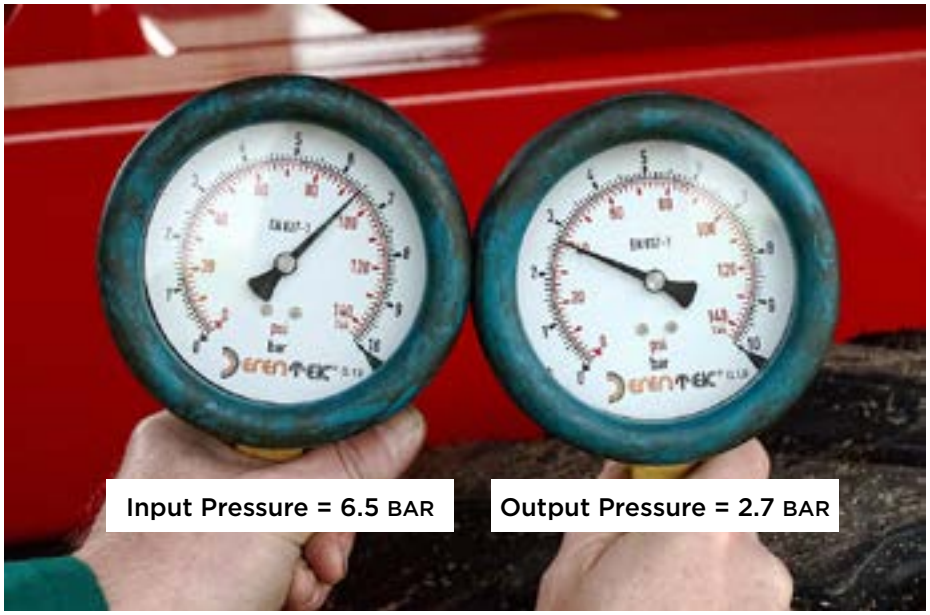


Fig.26 Load Sensing Valve (LSV) input and output pressure levels for an example unladen trailer

In these conditions the LSV output pressure should be:

- **Fully Laden** ▸ LSV Output should equal LSV Input pressure
- **Unladen** ▸ LSV Output should be approx. 25 – 35% of Input pressure

(Unless manufacturer's recommendations state otherwise)

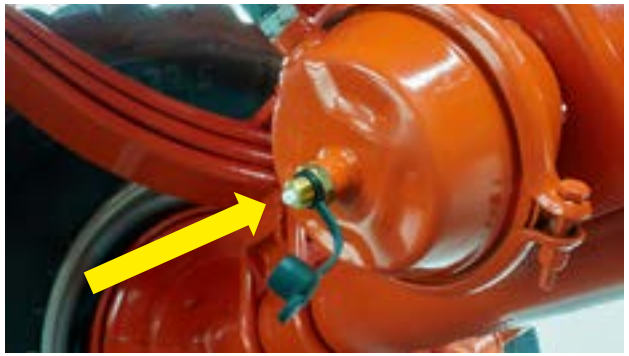


Fig.27

LSV output pressure test point on a brake actuator (air chamber)

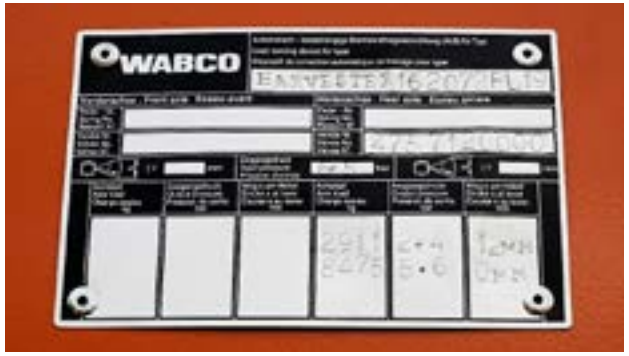


Fig.28

LSV setup information plate

The same approach is followed when checking either pneumatic or hydraulic LSVs. Pressure test points may be located near the LSV (usually the case for hydraulic LSVs). If not it may be necessary to measure LSV output pressure at a brake actuator (see Fig.27). Helpful trailer manufacturers may fit a chassis plate stating what the LSV input and output pressures should be when the vehicle is laden and unladen (see Fig.28), but currently not all do.

Important Bottom Line

If you are unsure about how to perform this procedure, consult the vehicle manufacturer or a specialist, BUT do get the LSV checked – Braking Performance depends on it

10. Older Trailers and Newer Tractors – a Problem?

Watch the video

Who hasn't got an old trailer somewhere around the farm? Exactly! What do we mean by an older 'legacy' trailer? Well, something you would expect to use at harvest behind a 40 or 50 km/h tractor and which probably ticks the following boxes:

- Useful capacity (14 tonnes or more): body in good condition
- Fitted with decent-sized (commercial, S-cam type) brakes and axles
- Probably not fitted with Load Sensing
- **DEFINITELY NOT** an old lorry chassis and body with a drawbar welded on it!

This description applies to plenty of current UK trailers. Those with another 15– 20 years of frontline use ahead, but which can only achieve 25–35% braking efficiency on a good day – when tested using the correct procedure (see Section 11).

10. Older Trailers and Newer Tractors – a Problem? - cont.

Where's the problem?

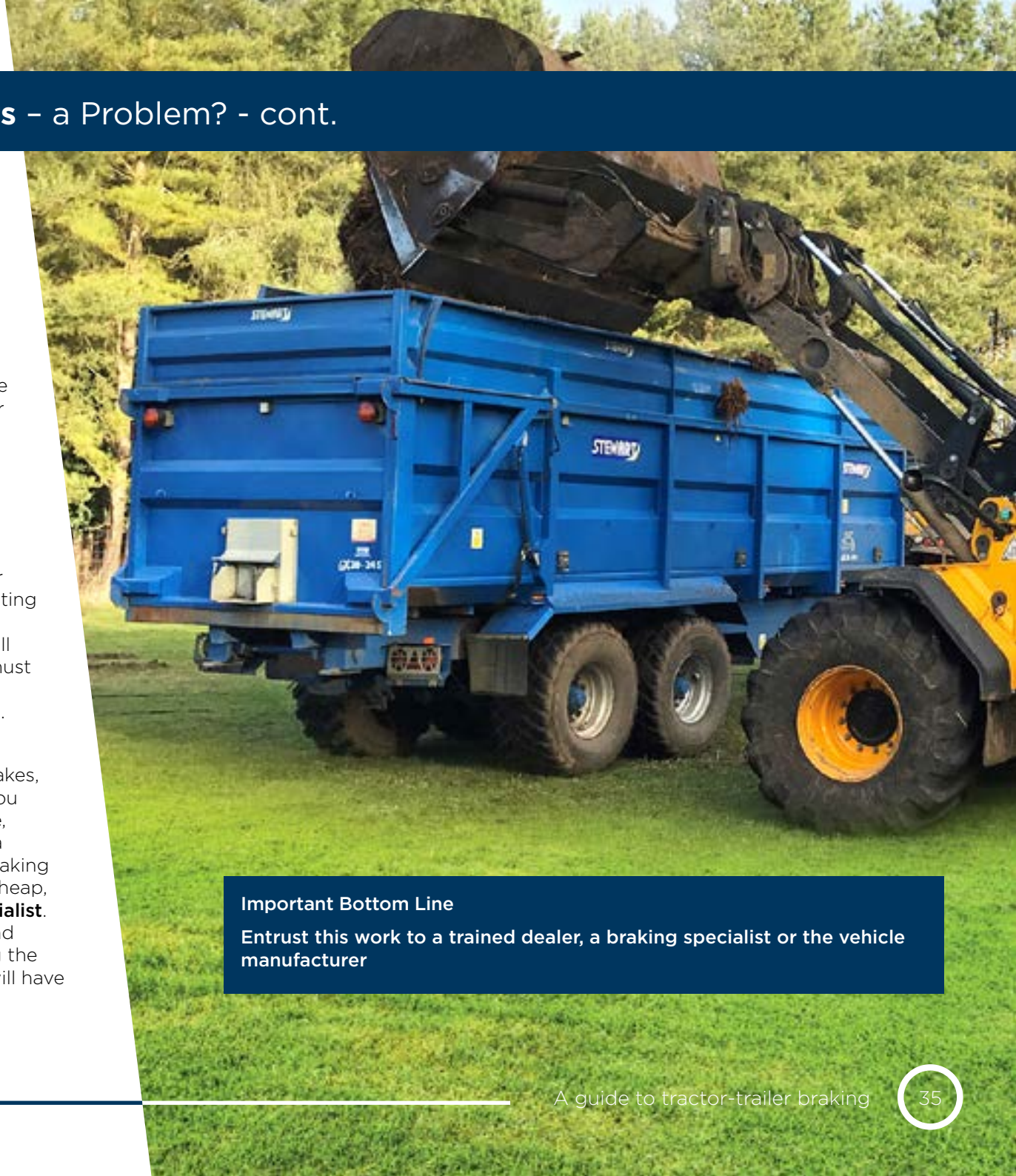
Sooner or later a new tractor arrives in the yard. Then, when a legacy trailer is hitched up to it, the trailer's brakes don't seem to work quite as well as they did behind the farm's older tractors. No, you're not imagining it and, no, there's nothing wrong with the new tractor. It's just that you're now seeing the true nature of the trailer's braking system.

So what has changed? Before the EU Braking Regulations were introduced, tractor manufacturers often set their Tractor-Trailer Brake Valves (TTBVs) to deliver higher (boosted) pressure during gentle braking. This partly compensated for the poor braking performance of many older trailers, and helped to protect the tractor's brakes. **BUT** it also made users think their trailer brakes weren't so bad, which probably wasn't the case.

The pneumatic (air) and Dual-line hydraulic TTBVs fitted to tractors built since Jan 2018 must deliver pressure to the trailer more gradually during light-medium braking, so pressure-boosting is now a thing of the past. That's not such a bad thing either, because new trailers now know exactly what pressures they will receive from the tractor and what braking performance they must develop to match. The trouble is, the 25-30% efficient braking systems of many current UK trailers are not quite up to the job.

What's the solution?

Actually it can be straightforward. If the trailer's foundation brakes, axles and suspension can cope with higher braking loads, all you need to do is upgrade the brake actuation system: for example, fit larger brake actuators and a load sensing system. But wait a minute! There is more involved than a trip to the local trailer braking Pick 'n Mix counter. The necessary components are relatively cheap, **BUT their selection and installation is a job for a trained specialist**. Precise brake performance calculations are required beforehand and the trailer's braking performance **must be tested** following the modifications, to verify that everything is OK. Otherwise you will have no idea if it's better or worse – or even illegal!



Important Bottom Line

Entrust this work to a trained dealer, a braking specialist or the vehicle manufacturer

11. Braking System Inspection, Maintenance and Testing

Watch the video

For far too long, trailers and their braking systems have been seen as simple pieces of equipment. Yes, we all know they need to be maintained, but there's not always the time to do things thoroughly. That approach may have seemed OK in the days when 20 mph tractors pulled 8 ton trailers, but farm equipment has changed …. and so must your maintenance and testing procedures.

Inspection and Maintenance

These are two sides of the same coin. Regular inspection of a trailer's braking system (and other components), checking for leaks, wear, excessive system travel, etc. is a vital maintenance activity. Always keep written records of regular checks and any more involved work requiring component disassembly. A helpful trailer/trailed implement 'Health Check' form for regular checks can be downloaded from **https://bagma.com/resources/**

Instruction manuals are available online from major trailer and axle/brake manufacturers, detailing specific inspection/maintenance activities and their recommended frequency. These vary according to system design. Correct component operation may need checking daily and/or weekly and especially before intensive use. Do not take anything for granted!

Every year, remove the trailer brake drums for component cleaning, lubrication, wear assessment and adjustment. Check the drum, the brake shoes/friction linings, return springs, camshaft and wheel bearings. 'Out of sight' should definitely not be 'out of mind' (see Fig.29). If a Load Sensing Valve (LSV) is fitted, check that as well.

System Performance Testing

Braking system inspection and maintenance is only part of the story. You may now know that the components are all there and in an acceptable condition, but how do you know if the system will deliver enough braking performance? Even if you've checked the LSV's input & output pressures, do you know if the brake actuators are the right size or if the braking system was set up correctly at the factory? Or if something in the setup been changed since then?

In reality you don't know. Not least because in the UK, new trailers and trailed implements can be sold without verification of braking system design or performance. Would you buy a car or a tractor in such circumstances?

Still, help is at hand. Trailer/trailed implement braking performance can be tested easily, either by:

- A BAGMA-accredited agricultural dealer, trained and equipped for agricultural trailer (and tractor) brake performance testing (see Fig.30)
- An HGV authorised testing facility

Both will measure the trailer's Braking Efficiency, but in order to obtain an accurate and meaningful test result, it is **very important** that:

a) The trailer is fully laden during the brake test – because this is the condition in which the legal (minimum) braking efficiency must be achieved (see Section 5)

b) The trailer brake line pressure during the test is carefully held at:

- Air brake systems – 6.5 bar in the Yellow 'Control' line
- Hydraulic systems – 100–115 bar in the 'Control' line

- Unless these steps are followed, you won't get a true assessment of vehicle braking performance.

Fig.29 Damaged/overheated trailer brake friction lining

Fig.30 BAGMA BrakeSafe braking performance tester

Key things to check during trailer braking system maintenance

This list is not exhaustive and certainly does not replace manufacturer's recommendations. But at the very least you should check (or have someone check) the following:

Brake Hoses, Fittings & Line Filters:
Check for damage & leaks. Disassemble & clean Line Filters

Relay-Emergency Valve (air brakes):
Service brakes should apply when the Red 'Supply' hose is disconnected. Following an initial outrush of air, no further airflow should be noted

Load Sensing Valve:
Correct Input and Output pressures should be produced both when the trailer is fully laden & unladen

Shunt Valve (air brakes - if fitted):
Should release the Service brakes. Should return to original position when brake hoses are reconnected

Brake Actuator Free Travel:
No more than 50 mm or two-thirds of actuator maximum travel should be required to apply the brakes fully. Brakes must not drag when released

Brake Drum removal:
Drum should not be cracked or excessively worn. Brake dust/debris should be removed from internal components **(Caution: Wear appropriate PPE)**

Brake Friction Linings:
Lining thickness should be within acceptable wear limits. Surface not glazed or contaminated

Overall System Performance:
Braking Efficiency should be verified **annually** by testing at the **correct** line pressure values

Tractor (Trailer) Brake Couplings:
Deliver the correct line pressures from the TTBV to the trailer – The trailer braking system can't do its job unless it receives the correct supply and control pressures

AND FINALLY:

Most braking system maintenance can be done on-farm if staff have received the right training - and suitable courses are readily available. Trailer braking systems are not so very complicated, but they are safety-critical and a little knowledge can sometimes be a dangerous thing.

So if you're not 100% sure how to do the job, leave it to a trained specialist ..... But do get it sorted!

12. Summary

This guide provides an informative overview of tractor-trailer braking, rather than a comprehensive reference. Amongst other things it has highlighted:-

- The overall, practical requirements of a tractor-trailer braking system
- How increasing vehicle speed or weight can have vastly different effects on braking system load
- Current braking legislation and regulations
- The different types of tractor-trailer braking system used in the UK
- The importance of selecting the right size and type of trailer axle brakes for your application
- How trailer braking performance can be limited by brake actuator size and system adjustment
- Why a Load Sensing system is so important and why its performance should be checked
- Possible problems with the braking performance of older trailers when towed by newer tractors
- Essential steps to follow regarding braking system inspection, maintenance and testing

That's a lot to take in and act on, but the consequences of ignoring a braking system can be serious. Whilst tractor-trailer braking systems can be complex, they are relatively cheap to purchase and install and easy to maintain, **given suitable training and if necessary, specialist help**.

However, the consequences of doing nothing (or the wrong thing), can be a huge financial cost or - much worse - ruined lives. Accidents can happen, but selecting the right equipment and keeping it well-maintained and tested will reduce their likelihood. Taking these critical steps will protect not only your equipment and your pocket, but also your staff and the general public.

Remember, in the eyes of the law, ignorance is never a valid excuse or defence. So having read this guide, can you answer the following questions? If not, have another look at the section(s) indicated:

1) Do you know the braking performance (braking efficiency) of your tractors and trailers? If not, do you know how and where you can get it measured? (Section 11)
2) Does the performance (braking efficiency) of your trailer brakes match that of your tractor? What are the likely consequences if it doesn't? (Section 3)
3) What effect will towing a trailer at 50 km/h (30 mph), rather than at 40 km/h (25 mph), have on your trailer's brakes? (Section 4)
4) Do you know what type of brakes/braking systems your trailers have? Given the way that you use those trailers, is that what they should have? What are the differences between the different system types? (Sections 6, 7, 8 & 9)
5) Do any of your trailers or trailed implements need a Load Sensing system? If they already have one, do you know if it is working correctly? (Section 9)
6) What should you do, on a regular basis, to make sure that your tractor-trailer braking system continues to work properly and delivers the correct performance? (Sections 9 & 11)

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