

# Development Trends of Trailer Axles and Suspensions

## 1 Introduction and targets

There are a lot of development trends and there are some more development engineers who have their own opinion about this subject. But they all have the same two targets. This is safety and economy.

Safety means, that the driver should have no breakdowns. This might cause accidents. And safety also means a good brake behaviour - the brake should answer quickly and with high performance. The brake should not fade at high temperature and it must be compatible to truck brakes. And safety also means, that the suspension has to allow a good driving behaviour - this means good steer stability and low vertical acceleration.

Economy means low costs - investment cost and operating cost. There might be sometimes a target conflict between investment and operating cost. So you carefully have to look at the total costs. Some examples for economy trends are light weighted design, which leads to more payload or easy to replace spare parts, which reduce the maintenance costs.

This report will give an overview about some selected development trends. Some of these trends are well known - for example the trend to air suspension. Other trends are relatively new - for example the disc brake. This report will start with the better known trends and go to some newer trends.

## 2 Trends of modern suspensions and axles

### 2.1 Trend to air suspension

The market share of air suspension is more and more increasing. There is a strong trend to air suspension. This is because air suspension has in contrast to conventional leaf spring suspension a lot of advantages.

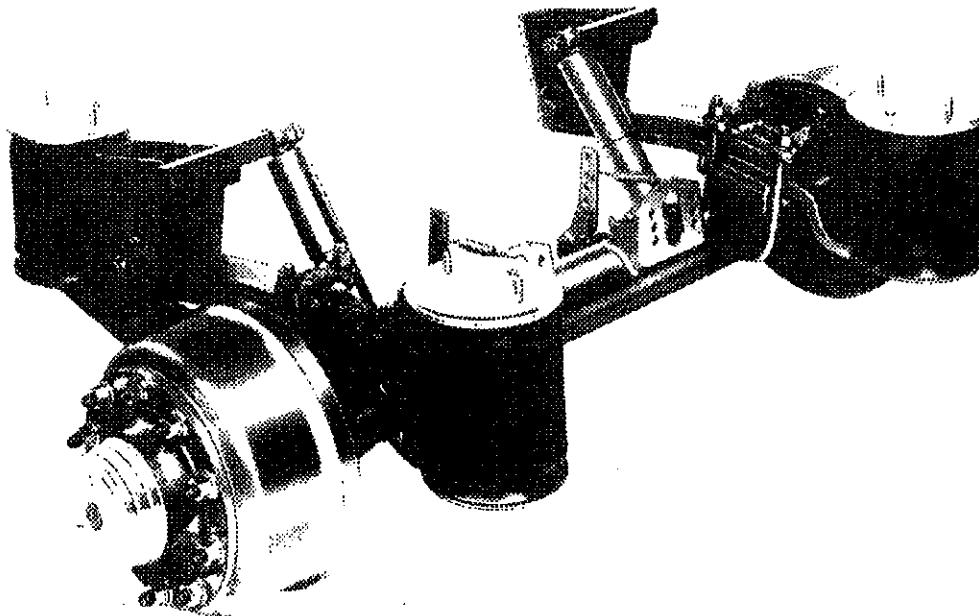


Figure 1: A typical air suspension

#### Description of air suspension

A typical air suspension is shown in figure 1. The axle body is clamped with u-bolts and flanges to the trailing arm, which are on both sides of the vehicle. At the end of the trailing arm the air bag supports the vehicle frame, which is not visible in the picture.

#### Low vertical spring rate

The vertical spring rate of such a suspension is relatively low. This is because of the smooth air bag, on which the axle load mainly lies. Normally you cannot achieve such smooth spring rate with leaf springs. And there is an additional advantage. The air spring rate increases proportionally with the load, in contrast to the leaf spring suspensions. Unladen or laden there is always an optimal spring rate. All these things result in maximum protection of the load, vehicle, driver and road.

### Ride height control

Another advantage of air suspension is the possible ride height control. Each load variation initially leads to a change in the ride height. But by means of automatic charging or venting the air bag the ride height is regained very quickly.

### Brake load equalisation

On multi-axle assembly configurations the air bags are interconnected by equalisation lines. So an exact axle and brake load equalisation is reached. Even with extreme chassis inclination or on very uneven road surface the axle load is just the same. This means, that the braking action is the same at all axles too. The brake balance between truck and trailer can be much better adjusted with air spring because the axle load is exactly defined by the air bag pressure.

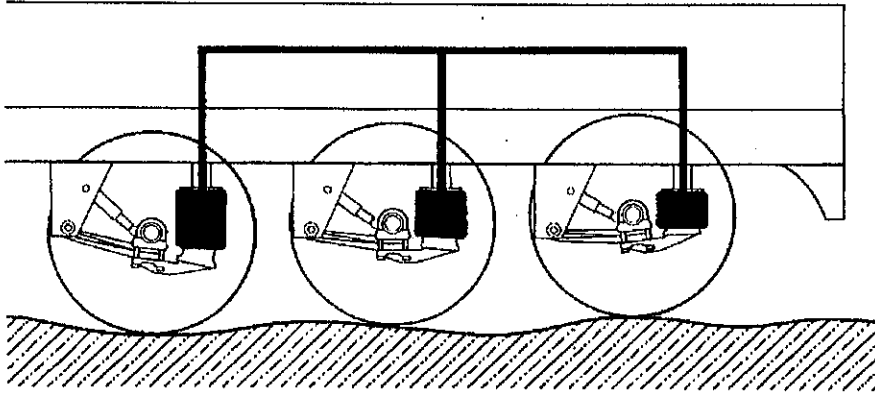


Figure 2: Brake load / force equalisation

### Load dependent damping

The damper force of conventional damper depends on the damper speed and the damper itself. There was no influence from the load. Conventional dampers are designed for the maximum load. But this always means, that the unladen trailer has much too high damping forces. This leads to riding comfort, which is not optimal. But now there is a new damper generation. These dampers are controlled by the pressure in the air bag. There is a simple connection between air bag and damper - no additional sensors or electrical or electronic devices. Automatically adjusted the damper force is variable an optimal over the full axle load range.

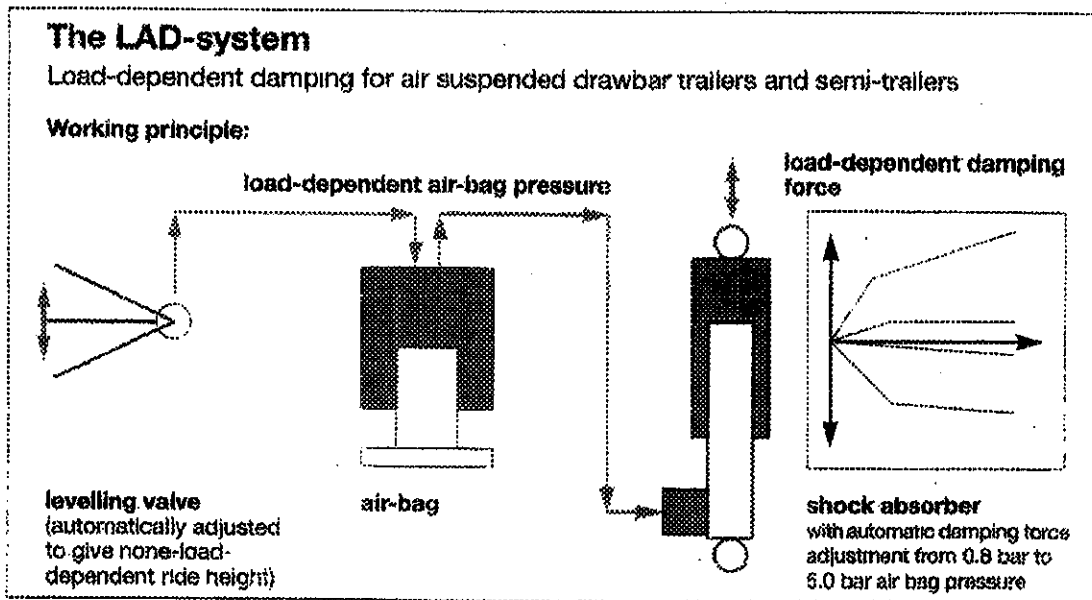


Figure 3: Load dependent damping

### Axle lifting device

For travel with empty or partially filled container, axle lifts permit one or more axles to be raised of the ground. This doesn't protect only the tires of the raised wheels, but also prevents excessive wear of the other tires as a result of reduced steering errors.

### Suspension weight

Nowadays a modern air suspension is lighter in weight than a leaf spring suspension. Depending on the ride height, single or double leaf spring, drum size and others it weight between 400 and 500kg.

#### Trend to lower ride height

In picture 1 the axle is above the trailing arm. In an alternative design the axle body lies below. This depends on the ride height. The ride height defines the height between vehicle chassis and the axle centre. In Europe there is a strong trend to reduce the ride height. On one hand this is because of the coupling height. Coupling height come down, because of more load volume. On the other hand there is a demand to reduce the chassis weight. This could be fulfil with higher frames combined with smaller wall thickness. The author expect an optimal ride height for 22.5" axle between 300 and 360mm.

## 2.2 Trends of roller bearing technology

Conventional hubs are equipped with two roller bearings, one larger one at the inner side and one smaller one at the outer side. After mounting these hubs these bearings have to be adjusted. The exact axial clearance of this adjustment has a very big influence of the fatigue life. For example: 0.5mm axial clearance means to reduce the fatigue life to 50% of the nominal fatigue life time. If there is dust in the bearing the life time will be also dramatically reduced. These facts are well known and are part of several studies.

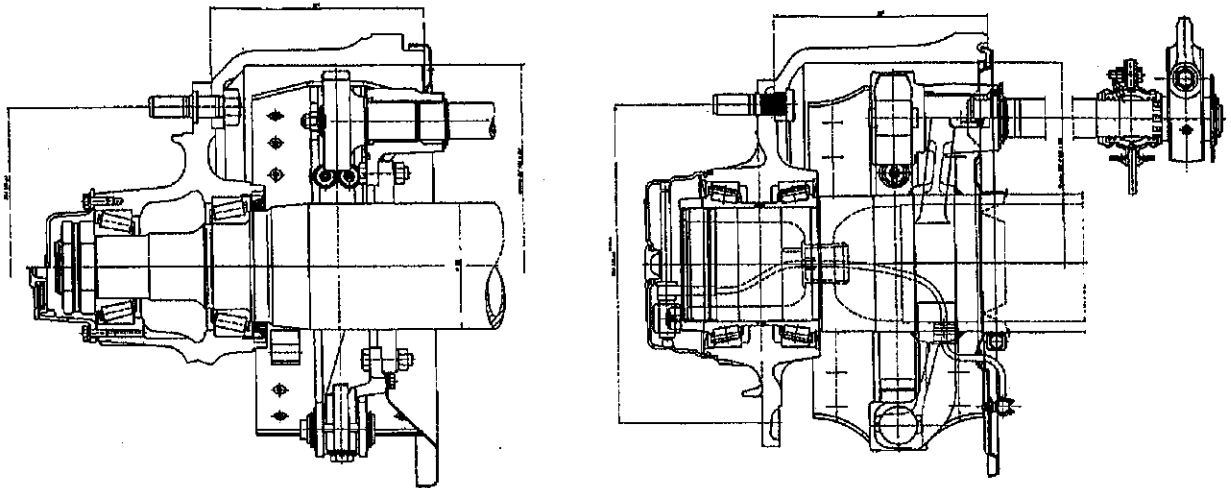


Figure 4: Conventional bearing and Hub unit

These problems can be solved with sealed pre set hub units. The principle of these units is easy. The length of the inner bearing ring is very exact machined. It fits to the length of the outer ring. The exact machining leads to the pre-adjusted bearing. The clearance of the bearing never changes while riding. Mounting this hub is easy. The worker pushes it on the axle spindle and screw the nut tight. On the right hand side of the axle there is a ride hand nut and on the other side there is a left hand nut. So there is no way to loose this nut. The errors in bearing adjustment are eliminated.

Hub units are sealed. There is a special lubricant in this hub, which is good for a long time. SAF uses such units for a few years. Our experience is that such units are good for 500,000km or 50 month free of maintenance.

## 2.3 Development trends of drum brakes

A modern drum brake should be in that way designed, so that it could be maintained only in a few minutes. An axle, that is easy to maintain is shown in figure 5: For routine brake service, simply remove the hub cap with a screwdriver, then the axle nut and finally draw the hub bearing assembly including the wheel, tire and brake drum. The bearings are sealed and protected against dirt. Now remove the strap spring and brake shoes can be re-lined or replaced. Reassemble by the same procedure in reverse.

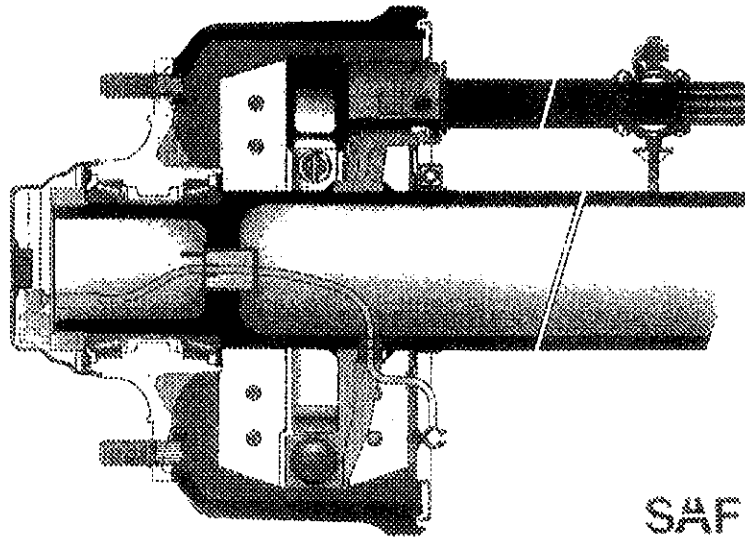


Figure 5: SAF SK RS 9042

## 2.4 Development trend of disc brakes

Disc brakes fulfil the demand to more safety. In comparison to drum brakes there are mainly two big technical advantages: At first disc brakes are very heat resistant. There is almost no fading at higher temperature. And second disc brakes are insensitive against variation of the friction coefficient - this means for example that the brake performance of the left brake is always near by the power of the right brake. These are the main reasons, why disc brakes will be installed in trucks. Some internal studies show, that in a few years most of the European trucks will have disc brakes on front and rear axles.

But do we need disc brakes in trailers too? Higher brake performance is a big advantage but disc brakes have also higher investment and operating costs - at least in trailers. In this context we have to answer a very important question: What will happen when a trailer with drum brakes is connected to a truck with disc brakes?

Before answering these questions it will help to have a look how a trailer disc brake looks like and check out the exact performance data.

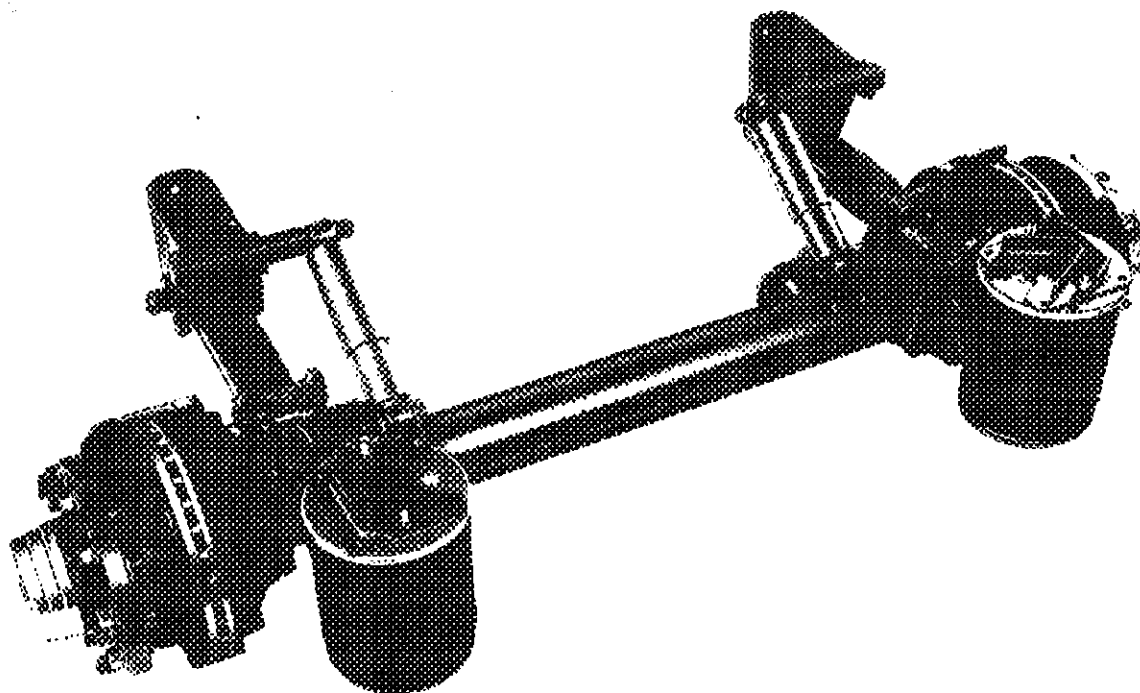


Figure 6: Trailer axle with disc brake SKRS 9022

In figure 6 there is a trailer axle with disc brakes. Axle capacity is 9t and designed for 22.5" wheels. This axle is integrated in a standard air suspension. This disc brake is pneumatic controlled. The brake caliper moves on the brake support. The brake cylinder is bolted to the caliper and moves with the caliper while operating. The brake works like a

screw clamp: clamp one side and the other side will be clamped automatically. Today most of the pneumatic controlled disc brakes work in this way.

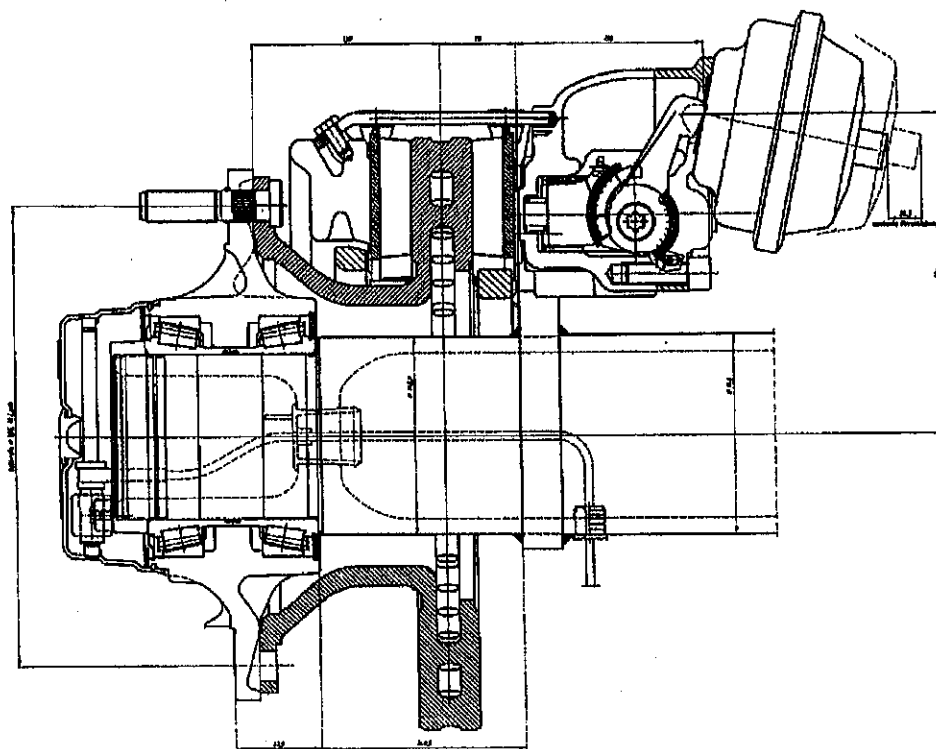


Figure 7: Disc brake SKRS 9022

Figure 7 shows a cross section through this brake. The disc is directly bolted to the hub with the wheel studs. The outer diameter of this disc is 430mm. The disc is 45mm thick and for better cooling there is an inner ventilation. This disc has a special material, which is developed for such discs. It is very heat resistant.

With discs there will be no fading problems like known from drum brakes. When a drum becomes hot the outer diameter is increasing. The clearance between brake shoe and drum is also getting wider and the brake fades. Disc brakes have a total different behaviour. The disc width also increases with the heat. Then the clearance between disc and brake pads is going tighter. So there will be no fading.

Beside the disc there are the brake pads. The life time of such brake pads is near by the life time of brake shoes. Today there is no significant difference in the wear. For replacing these pads the wheels including their nuts have to be removed. Then the bolt including the brake pad bow have to be removed. This procedure needs more time than replacing brake shoes.

In the figure right beside the pads there is a lever. On one side this lever is actuated by the brake cylinder, which is bolted to the caliper. On the other side the lever is eccentric supported. While actuating the brake this lever turns and pushes against the plate. This plate is connected with two pistons, which are not shown in the figure. The push force of the inner pad is approximately 16 times higher than the force of the brake cylinder. The reaction force pushes the outer brake pad against the disc. The maximum torque of this brake is 20000Nm. Hysteresis is because of the integrated roller bearing very low. It is approximately 6%.

The wear of the brake pads and the disc will be automatically adjusted but how this works will not be in this paper.

Axles with disc brakes have been integrated in several trailers. SAF has made a lot of testing in lab and on road. One standard test has been made in the German Alps. There is a 12km long pass with 8% slope, called Rossfeld. There SAF tests disc brakes as well as drum brakes in their trailers. There are also trucks, some with disc brakes and others with drums.

The following test has been made in order to compare the brake performance. Full loaded truck and trailer ride downhill with a speed between 20km/h and 40km/h. The driver actuates the brake when speed is 40km/h and brakes until speed is 20km/h. The result of this test show what will happen when a vehicle with drum brakes is connected to a vehicle with disc brakes.

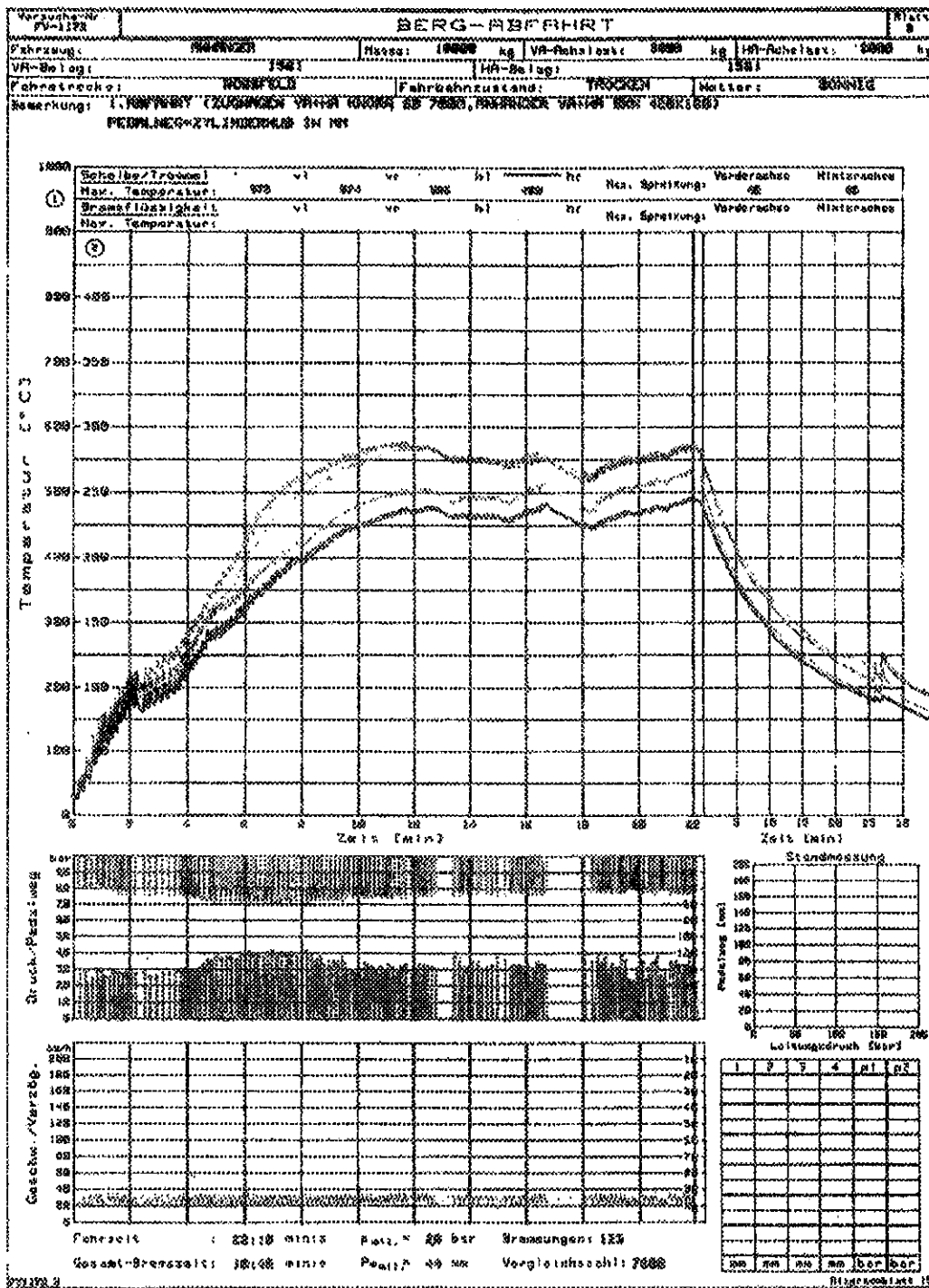


Figure 8: Brake temperature while braking - drum brake

Figure 8 shows the drum temperature while braking. While testing in the first 5 minutes the temperature increases steady up to approximately 350°C. Then the brake begins to fade and the brake cylinder strokes increases. At approximately 600°C the drum brake has achieved its end.

In contrast figure 9 shows the same test with disc brakes. This brake achieves much higher temperatures up to approximately 1000°C while the brake cylinder stroke decreases!

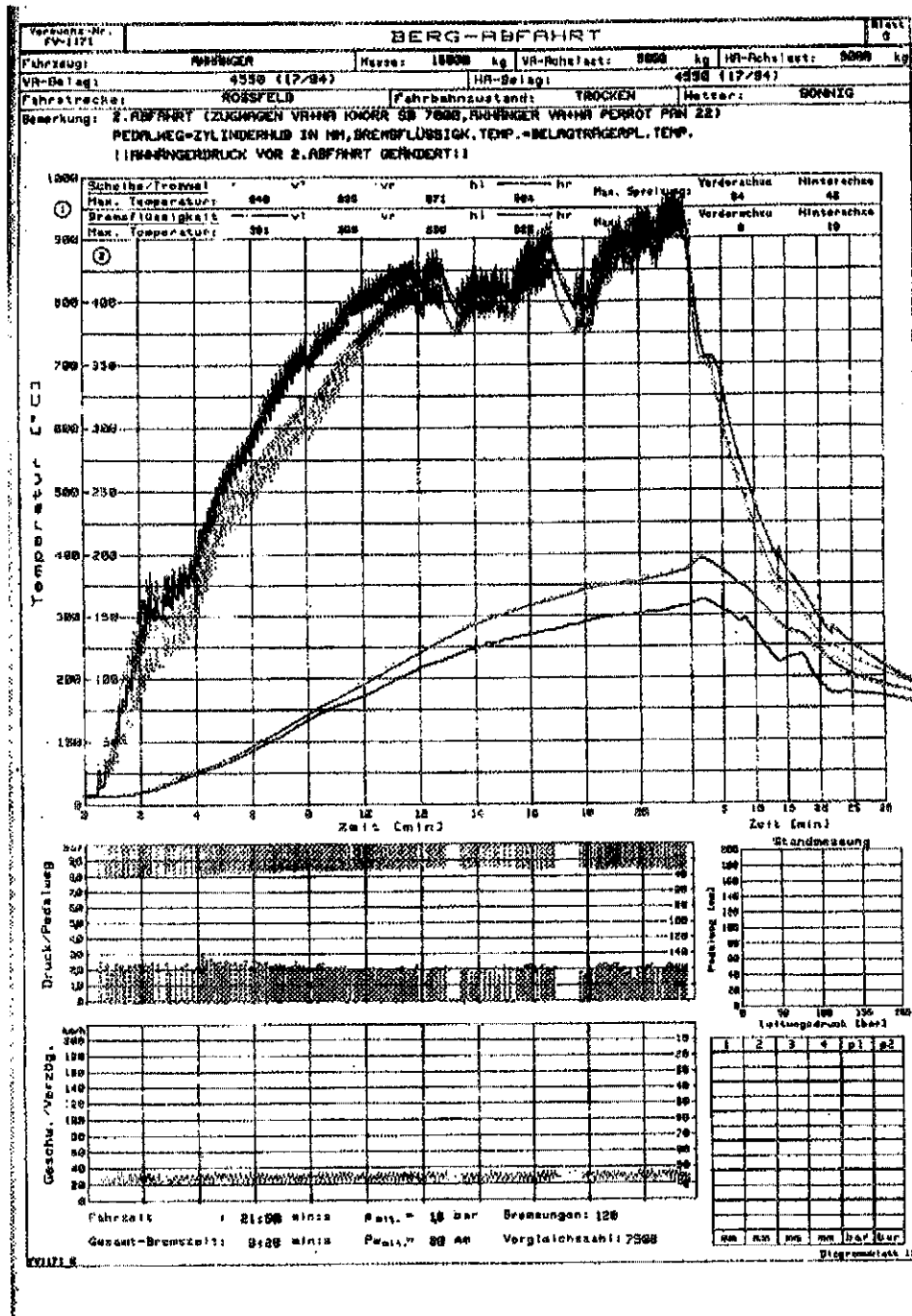


Figure 9: Brake Temperature while braking - disc brake

The conclusion is: When coupling two vehicles with different brake types there will be normally no significant brake problems. But if the driver uses his brakes excessive at higher temperature then this could change. Normally then there will be a wear problem at the disc brake.

Today at SAF it is up to the customer what brake type he prefers. Disc brakes have a better brake performance but today drum brakes are more economical.

### 3 Summary

Safety and economy are the main targets while developing trailer axles and suspension. These demands will be fulfilled by air suspension, which has a lot of advantages in contrast to conventional leaf suspension. In order to reduce the operating cost there are a lot of new features on trailer axles: For example hub units or modern drum brakes, which are easy to maintain. With disc brakes a higher brake performance can be achieved. Under normal conditions vehicles with disc brakes can be coupled with vehicles, which are equipped with conventional drum brakes.

by Dr. Chris A. Frey, SAF Germany