

## State-of-the-art in commercial vehicle pneumatic disc brakes

### Introduction

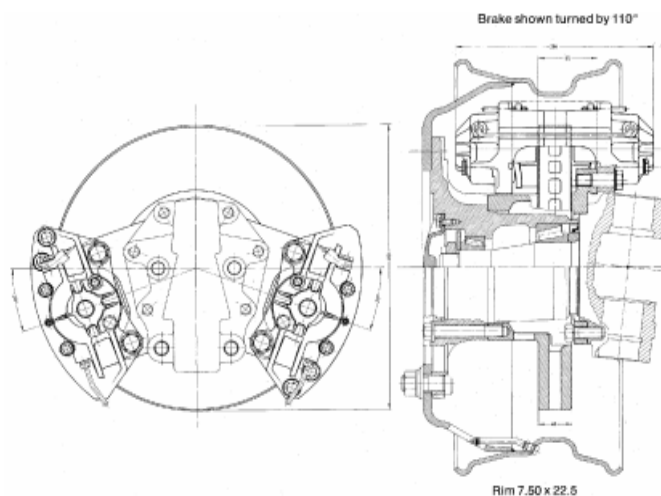
In terms of disc braked vehicles the 1960's was a significant decade. At the beginning of the decade, in 1961, the smallest hydraulic disc brake was introduced on the Austin Mini Cooper passenger car – 178 mm diameter disc in a 10" wheel – and at the other end of the decade in 1969 Knorr-Bremse exhibited a floating caliper hydraulic disc brake for heavy commercial vehicles – e.g. 410 mm diameter disc in a 22.5" wheel – with series production commencing in 1973. A fixed caliper design followed in 1980 and by 1986 some 50,000 units had been sold.



10" and 22.5" wheels

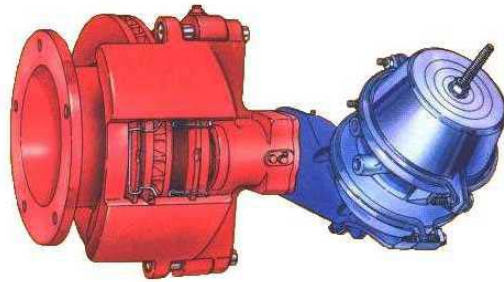


Knorr-Bremse fixed caliper hyd. disc brake



Knorr-Bremse 4K85 hydraulic disc brake on a 6t front axle

The late 1970's and early 1980's saw the development and application of the first air operated disc brake designs as it became apparent that providing a parking function with a hydraulically operated disc brake was a major problem area. Initial designs used an externally mounted lever (slack adjuster) to transmit the force from the brake chamber or spring brake actuator – mounted on a bracket attached to the caliper – into the caliper – into the caliper.



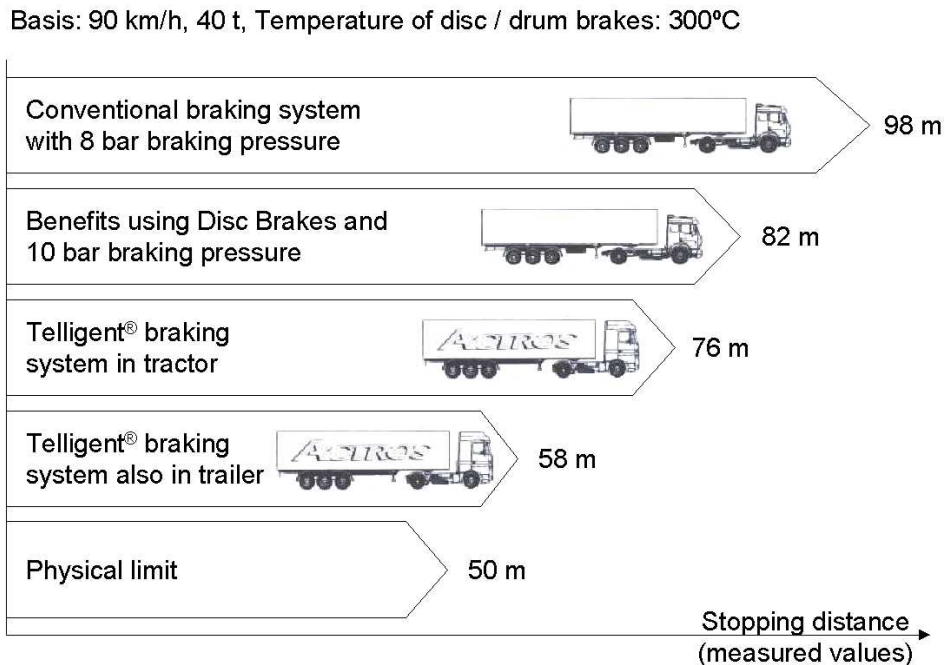
Rockwell Dura-Master air disc brake, ca. 1980

Take-up of these early designs was very slow due to packaging difficulties – especially front axles – and poor pad/disc durability. Not until the Knorr-Bremse SB7.... design with a directly mounted air actuator – first shown at the 1987 IAA in Frankfurt – entered series production in 1992 were these problem areas overcome.



Knorr-Bremse SB7... air disc brake

As development of the new Knorr-Bremse air disc brake proceeded it was not carried-out by Knorr-Bremse engineers sitting in splendid isolation, but in close partnership with various motor vehicle manufactures, particularly DaimlerChrysler. The work with DaimlerChrysler was focused not just on the disc brake, but on the concept of a Telligent<sup>®</sup> (intelligent) braking system as one part of the vehicle Telligent<sup>®</sup> communication system. As a prime mover of the Telligent<sup>®</sup> concept Professor Egon-Christian von Glasner was very much involved in ensuring that when the Mercedes-Benz Actros first entered production in 1996, the Telligent<sup>®</sup> braking system was fully realised. This realisation was achieved through the use of the Knorr-Bremse SB7... air disc brake – fitted to all wheels – together with electronic braking control (EBS).

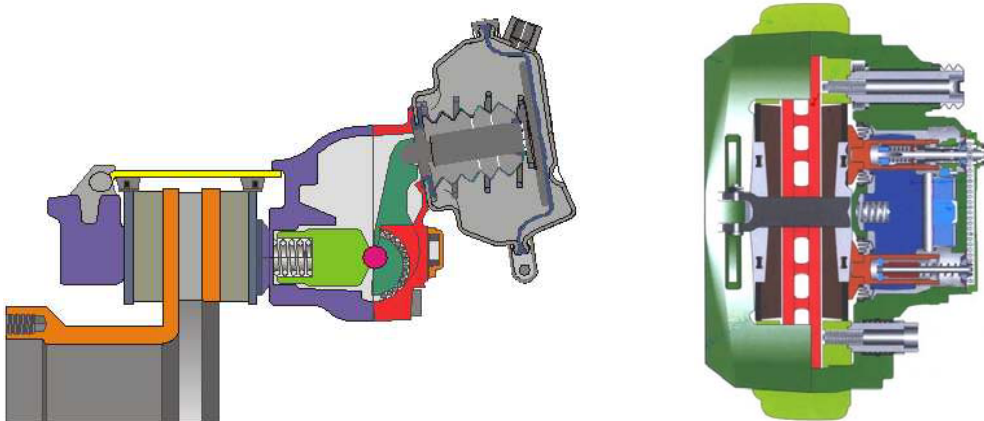


### Stopping distance improvement

In 1980 an industry wide forum known as the  $\mu$ -Club was formed for the exchange of ideas and information on all aspects of braking at a yearly symposium. Since its inauguration Professor von Glasner has been, and remains, a major contributor with his ideas on integrated braking/vehicle systems.

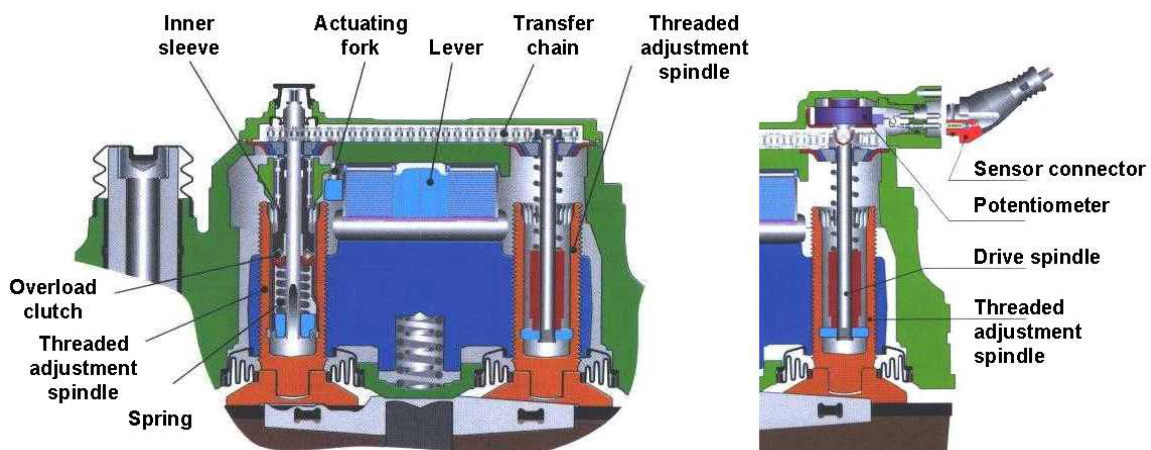
## The SB7... air disc brake

The SB7... is a floating caliper design for 22.5" wheels ( SB6... & SB5... are similar designs for 19.5" and 17.5" wheels) in which the directly mounted brake chamber or spring brake operates a lever pivoting in two roller bearings with a roller running in a plain bearing in the lever transmitting the operating force via a bridge piece and two threaded adjustment spindles into the inner brake pad. The operating force is transmitted to the outer brake pad by the caliper sliding on two pins mounted in the carrier – one running in a brass bush and the other in a rubber/plastic bush.



The running clearance between the pads and disc is maintained by an automatic wear adjustment mechanism mounted in one of the threaded adjustment spindles. The amount of necessary adjustment determined by the adjustment mechanism is reproduced in the second threaded adjustment spindle via a transfer chain. A manual override is provided to facilitate pad replacement.

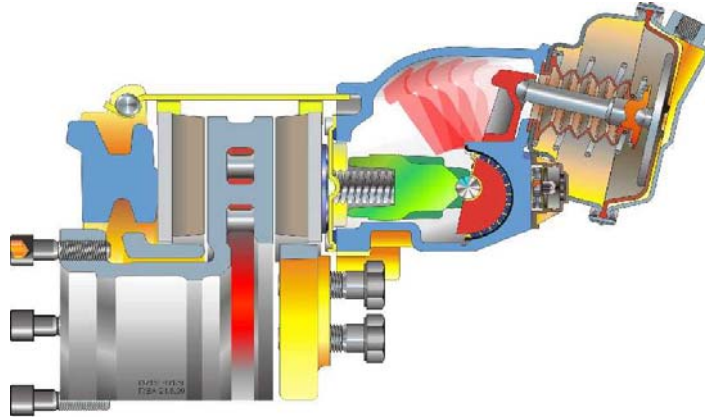
Wear indication can be of the on/off type with a sensor mounted adjacent to the inner pad or using a built-in potentiometer. The built-in potentiometer can also be a continuous signal type which when used in conjunction with an electronic braking system (EBS) e.g. Telligent<sup>®</sup> such functions as brake wear balancing can be carried-out.



**SB7... wear adjustment and wear sensing (potentiometer)**

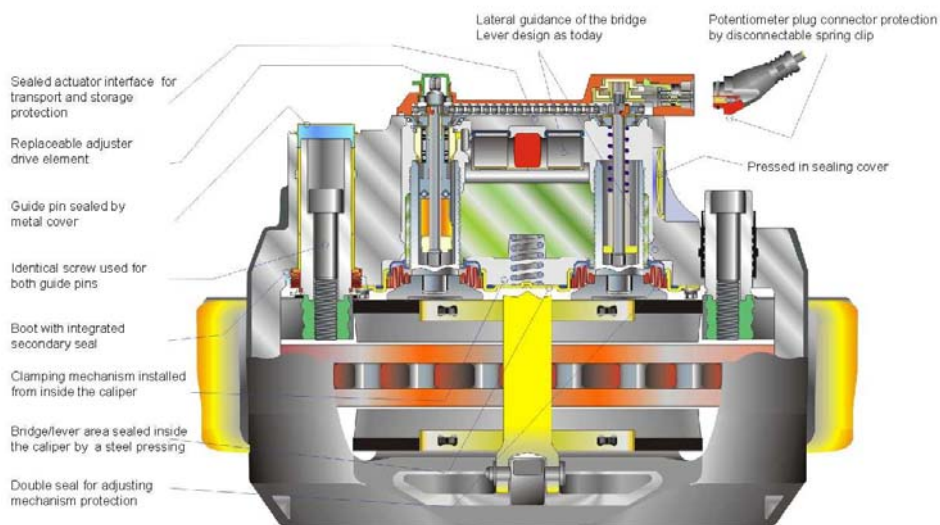
## The 2<sup>nd</sup> generation Knorr-Bremse air disc brake (SN7...)

The SN.... design is the latest series production air disc brake from Knorr-Bremse. It is an incremental development of the SB.... design utilising the experience gained from having more than 4<sup>1</sup>/<sub>2</sub> million brakes in service.



Knorr-Bremse SN7... air disc brake

The changes include a monoblock caliper body – the lever housing is integrated into the caliper body – improved lateral guidance for the bridge, a reinforced pad retainer, improved sealing for various items within the caliper and a transportation/storage seal for the brake chamber/spring brake interface when the brake chamber/spring brake is not fitted. To improve workshop friendliness, overload protection has been provided when resetting the adjustment mechanism by the inclusion of a replaceable drive element. Also, for the potentiometer plug connection a spring clip connection is offered as an alternative to 2xM4 screws. To improve pad and disc life in adverse operating conditions, a protective shield is available to protect the pads and disc when the brake does not sit inside the wheel. Supporting these technical improvements is  $\approx$  3kg weight reduction.



SN7... improvements

## The 'splined disc' and the 'split disc'

Not only has the caliper and the brake pad/disc friction interface been the focus of development effort, but also the design of the disc. Heat induced stress cracking and distortion resistance of the disc is a major factor in achieving optimum braking performance and durability. The traditional one piece hub and disc with its unevenly distributed volume is a very unsympathetic shape with regard to thermal expansion and heat dissipation. As a result Knorr-Bremse has introduced the 'splined disc' which separates the hub and disc into two distinct parts. Each part has an interfacing spline which are made fully compatible – in joining each other together as an assembled item – by the use of a number of intermediate elements. These intermediate elements allow the free radial thermal expansion of the disc, thereby reducing very significantly the possibility of heat induced stress cracking and distortion. They also inhibit the transfer of structure borne noise into the wheel hub. The result is increased service life and improved safety. Other benefits are an overall reduction in weight and the ability to standardise on the disc.

While changing brake pads is much simpler than changing brake shoes the same is not true of disc and drum. To change the disc it is necessary to remove the caliper and disassemble the hub, which in the case of hub reduction axles can be a complex and time consuming job. Therefore, as part of its disc design efforts, Knorr-Bremse has introduced in conjunction with the 'splined disc', the 'split disc'.

The 'split disc' as the name implies is a disc in two halves, that can be bolted together on the vehicle to replace the old disc without having first to remove the caliper or disassemble the hub. The one piece OE fitted 'splined disc' is removed by fracturing it in three places using a special tool installed in place of the brake pads and making a full brake application, having first removed the intermediate elements and created a stress notch in three places on the outer face of the disc. Fracturing is also used in a controlled manner in the manufacturing process of the 'split disc' to ensure that when assembled the two halves of the disc will be perfectly aligned. The holes that will eventually be used to bolt the two halves together are first drilled in the raw casting and the casting broken in half across the bolt holes. The two halves are then bolted together at the structural failure joint and the finishing process as per the solid 'splined disc' completed. The result is a split disc that once it is assembled to the vehicle has all the characteristics of a solid disc.



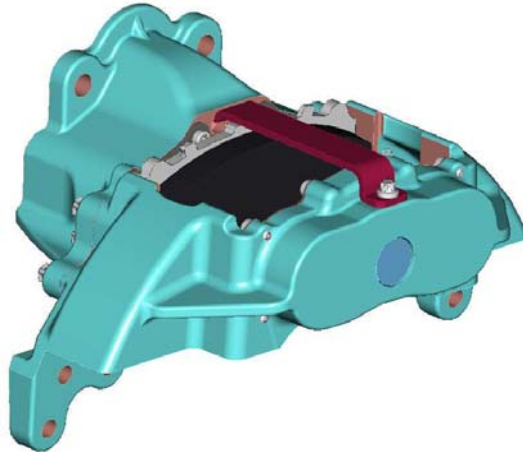
One piece 'splined disc' (OE)

'Split disc' (AM)

## Next generation air disc brake (S3G)

Development of the third generation Knorr-Bremse air disc brake – which like the first will be a revolutionary step forward – is currently underway in partnership with vehicle manufacturers. Its focus is an overall cost reduction for the end user in terms of reduced weight, increased durability and longer pad/disc life.

A fixed caliper design is being used to provide the weight reduction, e.g. no carrier, and the increased durability, e.g. improved robustness – no sliding guidance system. The longer pad/disc life will result from improvements in the control of the running clearance.



Knorr-Bremse S3G.... air disc brake

## Concluding remarks

Since its introduction in 1992 the Knorr-Bremse air disc brake has set the foundation brake standard for air braked commercial vehicles - trucks, tractors, buses, trailers and special purpose vehicles. This revolutionary design has not only set the standard in Europe – with Knorr-Bremse having nearly  $\frac{2}{3}$  of the market at the Big6 motor vehicle manufactures and producing over 1.3 million brakes per year – it is also setting a new global foundation brake standard. Today the basic design concept is followed by all other manufacturers of air disc brakes. Practically all heavy vehicles produced today in Western Europe are fitted with air disc brakes, and this will also be the case in the light and medium weight ranges with the introduction of new models.

With the introduction of the S3G design, air disc brake design for commercial vehicles will once more take a major step forward.

## References

- (1) Rockwell International, SP-8075 (11-80)
- (2) Rolf Povel, Egon-Christian von Glasner, Klaus Würst. Aktive Sicherheit von Nutzfahrzeugen – ein Update: XIV International Heavy Vehicle Conference, September 1997, Budapest.