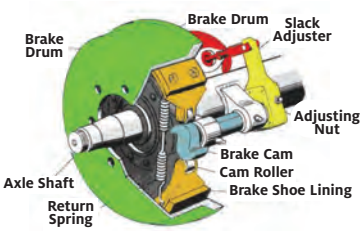
Advances in Vehicle Safety Technologies: Electronic Brake Monitoring for Commercial Air Disc Equipped Vehicles

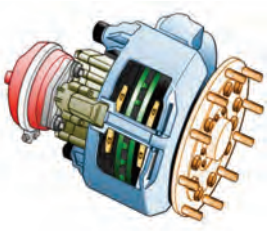
By **Thomas Wallace**, *Vice President,Electronic Braking/GM Transit Indian Head Industries, Inc./MGM Brakes*

1. Commercial Vehicle Air Disc Brakes Overview

Commercial air disc brakes are quite different from the more well-known s-cam (or drum brakes) that have been quite common in North America for many years. Air disc brakes, while offering many advantages to the fleet operator, also present unique difficulties and challenges when it comes to inspection and subsequent maintenance of these brake systems. Below are two illustrations showing a typical s-cam (drum), and a typical air disc application for modern commercial vehicles.



Drum (s-cam) Air Brake



Air Disc Brake

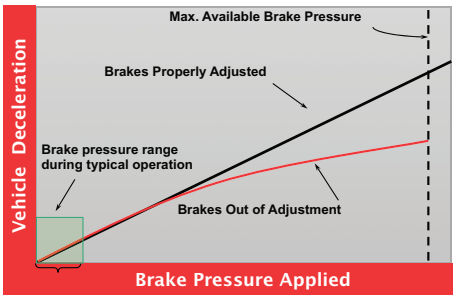
On the left you see a typical drum (s-cam) application that includes a brake chamber with an exposed pushrod, an automatic brake adjuster (ABA), a s-cam tube and bushings, a brake s-cam and cam rollers, linings and a drum. In this application, all parts are basically "exposed" which allows the fleet operator or inspector to visually check and inspect s-cam equipped vehicles using standard industry inspection criteria as defined by CDL requirements. Major component malfunctions can be checked and inspected visually by placing the vehicle on a lift (or over a pit) and actuating the brakes. The same process can also be accomplished through the use of electronic brake monitoring. CVSA has standard procedures for checking brake function and brake stroke for these applications.

On the right, you see a typical air disc application that includes a brake chamber with a fully enclosed pushrod, a brake caliper with an internal adjuster mechanism, a rotor and brake pads. This type of braking system poses unique challenges to the fleet in terms of visual brake inspections. There is no exposed pushrod in order to check brake chamber stroke, and the internal adjuster mechanism (designed to keep pad clearance constant like an ABA on s-cam systems) is fully enclosed, sealed and not possible to visually inspect. In addition, the pads and outboard rotor face are nearly hidden from view, making it difficult to check pads or rotor conditions visually without wheel removal for subsequent detailed inspections.
The industry has long known that a visual inspection of air disc brakes for proper operation is impractical, and this has been acknowledged by CVSA as a serious concern. The most common visually inspection method employed is simply to "check the rotor for rust" which would indicate the brake is inoperative *(can require wheel removal)*. Thus, with air disc brakes the fleet operator does not truly know with a visual inspection any of the following:

- The brake actuator (or brake chamber) is operative.
- The caliper internal adjuster is operative and maintaining pad clearance under all conditions.
- The wheel end is providing full braking, partial braking or no braking.
- The brake actuator (or brake chamber) stroke is within acceptable operating limits.
- The brake is lightly dragging (warning of other serious problems).

2. Why is Air Disc Brake Adjustment and Operation so Important?

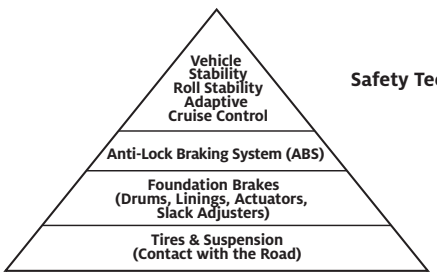
Proper brake chamber stroke is essential in order to ensure full braking capability. If, for example, the brake chamber is a 2.5" stroke actuator, once the pushrod stroke exceeds 2.0", the output force of the actuator drops rapidly resulting in reduced braking forces being available. Since most daily brake applications are typically between 10-30 PSI, the driver has no idea his brakes are out of adjustment until they are needed in panic situation. During a panic stop, 100 PSI or more is suddenly applied to the actuator and the brake actuator simply runs out of stroke. This could result in vehicle instability, excessive stopping distances and increased risks of collision. This is illustrated in the graph below. When vehicles brakes are in adjustment and properly operating, a fairly linear relationship between the brake pressure applied by the driver and deceleration of the vehicle exists (shown by black line). If, on the other hand, vehicles brakes are out of adjustment, the driver may not realize this until it is too late (shown by red line).



Relationship Between Brake Adjustment and Vehicle Deceleration

Just as critical in air disc applications is the internal adjuster mechanism inside the caliper itself. This adjuster mechanism is designed to maintain constant pad clearance as the pads (inner and outer) wear during vehicle use. If this adjuster fails, it can result in either *under adjustment* which leads to loss of braking force at the wheel end, or *over adjustment* which leads to a partially or fully dragging brake. In addition, internal adjuster mechanism failure can result in increased pad wear during normal vehicle operation. Without knowing the state of the caliper adjuster mechanism, the fleet operator (and enforcement inspector) does not know if the brake caliper is operating within specification.

Finally, the foundation brake system is critical to the proper performance of advanced technologies—such as ABS, Traction Control, Vehicle Stability Control and Collision Avoidance. These technologies all assume that the foundation brakes are fully operational when they attempt to intervene. If the foundation brakes are not properly operating, then these advanced technologies will not be fully effective when needed.



Safety Technology Pyramid

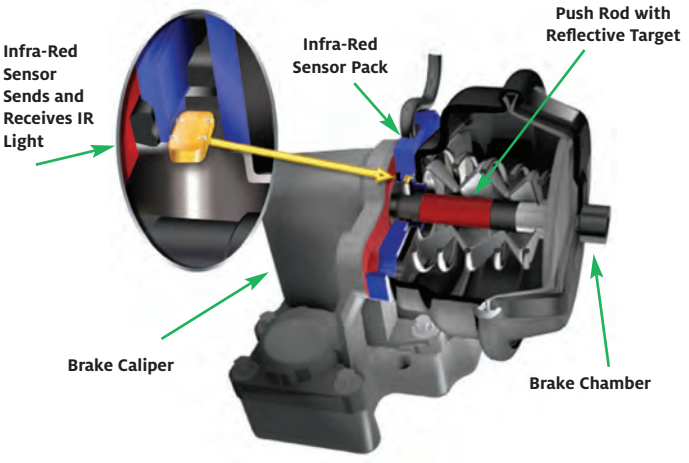
This is illustrated in the "Safety Technology Pyramid" shown below. Vehicle braking and stability is first determined by the tires and suspension, which determine the how much of the tire is proper contact with the road, followed by proper foundation brake operation and so on. The technologies further up the pyramid are dependent on the technologies below them to be properly operating in order for the more advanced technologies to be fully effective.

3. Current Air Disc Electronic Brake Monitoring Technology

Advances in electronics and integration into vehicle mechanical systems continue to evolve. Over the past several years, innovations in electronic brake monitoring have produced viable product offerings that withstand the rigors of commercial vehicle operation.

Below is an illustration of an Air Disc Electronic Brake Monitoring sensor installed at the vehicle wheel end. With this technology, an infra-red (IR) sensor is installed between the brake chamber and the caliper. This technology uses infra-red LED to send a light beam towards the brake chamber push rod, which is reflected back to the infra-red receiver in the sensor. The brake chamber push rod is coated with reflective (red areas) and non-reflective (black areas) materials. When the brake chamber pushrod moves back and forth under the IR sensor, a varying amount of light is reflected back to the sensor. This IR signal, when processed by the system Electronic Control Unit (ECU), can determine if the brake actuator and caliper are properly adjusted and working. This Electronic Brake Monitoring System can detect the following brake conditions at each wheel end.

- **Non Functioning Brake:** The driver depresses the brake pedal but the brake chamber is not properly activating *(caused by air system valve problems, ice in the air system, brake chamber failure, broken air lines etc.)*. **This condition can lead to increased stopping distances and potential vehicle instability.**
- **Over Stroke Brake:** The driver depresses the brake pedal, but the brake chamber is stroking beyond its acceptable limit *(caused by missing brake pads, missing rotor sections or brake caliper internal adjuster failure, etc.)*. **This condition can lead to increased stopping distances and potential vehicle instability.**
- **Dragging Brake:** The driver has released the brake pedal, but the brake chamber or caliper lever arm has not fully returned *(caused by air system valve problems, ice in the air system, brake chamber parking spring failure, caliper internal adjuster failure, etc.)*. **This condition can lead to hot wheel ends and potential wheel fires.**



4. Advantages of Electronic Brake Monitoring Technology

The vehicles in your fleet are one of your most valuable and costly assets, not to mention the liability implications if an accident or wheel fire does occur. Keeping your vehicles on the road—and ensuring they are operating safely—is critical in today's environment. Add the complexity of being able to fully visually inspect and maintain your vehicles air disc brakes, and a strong case can be made for electronic brake monitoring technology. The cost of one vehicle total loss, or associated liability costs of a vehicle collision, can quickly become a major expense. Electronic Brake Monitoring not only provides real-time brake system status, but also can significantly reduce maintenance costs by taking the repair technician straight to the problem, and finding brake problems before they become more extensive and costly.

Some advantages of Electronic Brake Monitoring are as follows:

- Allows for quick and accurate brake checks in conjunction with the vehicle pre-trip inspection
- Can save the fleet operator maintenance downtime and unnecessary maintenance costs
- Gives the fleet operator peace of mind knowing that the vehicles brakes are properly operating
- Can provide early warning of a thermal issue at the wheel end before it becomes serious

5. A Note about Brake Pad Wear Indication

There is often confusion in the industry about disc brake pad wear indication and what it can provide. Brake pad (or lining) wear detection will only report the thickness of the brake pads and cannot provide any information about brake status. Brake pad wear sensors simply report either the end of life of the brake pad or relative pad wear information (i.e. 50% of the pad remains etc.). These pad wear sensing systems, while beneficial, cannot provide any indication as to the status of the vehicles air system, brake chamber or caliper operation.

6. Conclusion

Significant technological advances in Electronic Brake Monitoring are occurring in the industry and these systems can provide significant benefit to the fleet operator and vehicle inspector. Being able to properly inspect and maintain your vehicles air brake system is one of the most important factors in making sure your vehicles are operating safely and to their maximum potential. CVSA is committed to working with fleet operators, vehicle inspectors and vehicle manufacturers in exploring new advanced technologies that can keep us all safe while we are on the road. ■