

UNDERSTANDING YOUR BRAKES: CONSIDERATIONS WHEN SPECIFYING AIR DISC BRAKES

Historically, air disc brake designs have not been optimized for the North American commercial vehicle market. In certain operating conditions, this can result in an air disc braking system that is less than ideal for today's lightweight trailers.

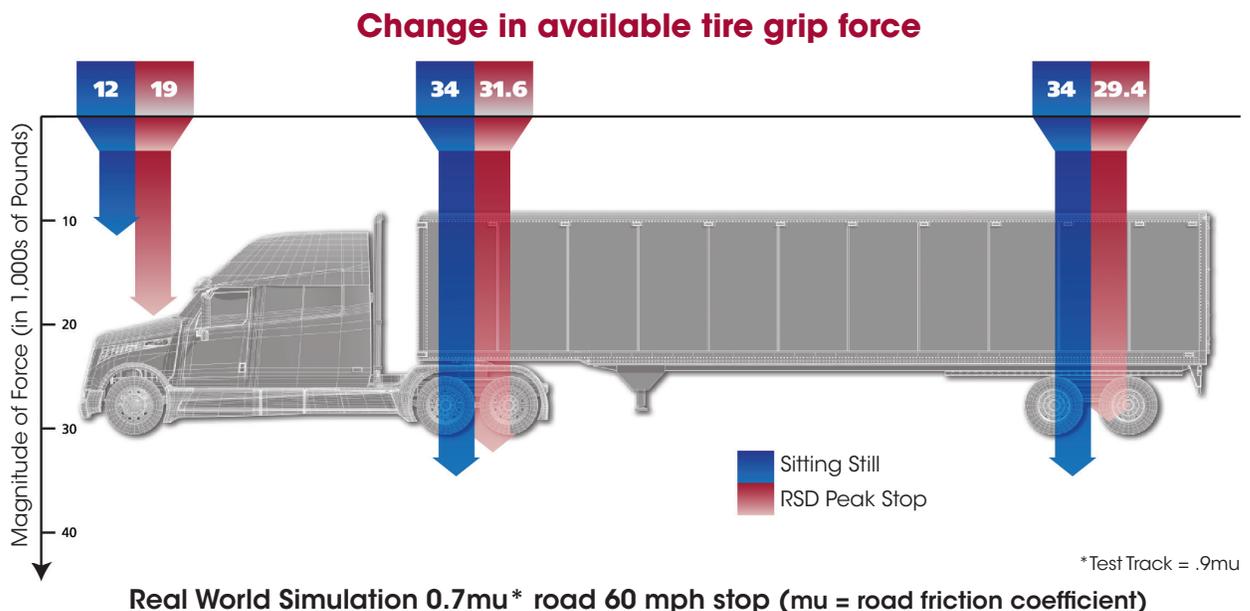
When placed in the correct operating environment, air disc brakes can be used successfully on today's modern commercial vehicle. Sizing the brake to meet the specific load carrying requirements of the trailer can improve the vehicle's average stopping distances. Distributing the work properly between the tractor and trailer can minimize thermal overload of the trailer brakes making a more robust wheel end that can result in longer service intervals.

By gaining a deeper understanding of the operating principles of both drum and disc brake designs, fleet managers are empowered to make more informed decisions when it comes to specifying equipment.

For decades, the classic S-cam drum brake has been the default standard on Class 8 tractors and trailers in North America. Although still appropriate for many applications, recent changes in stopping distance laws have created an increased awareness in commercial vehicle braking performance. As a result, fleets are investigating alternate technologies including air disc brakes. When sized correctly and used in the appropriate operating environment, air disc brakes can provide some enhancements over a typical S-cam drum brake system.

Some air disc brake designs adapted from Europe have not been optimally sized for commercial vehicle configurations in the North American market. Differences in wheelbase and number of axles on the tractor and trailer can have a profound effect on vehicle dynamics and the resulting brake setup needed to optimize performance. In general, a "one-size-fits-all" approach has dominated the air disc brake market in North America, which has resulted in some overly aggressive brake systems that are less than ideal for today's lightweight trailers.

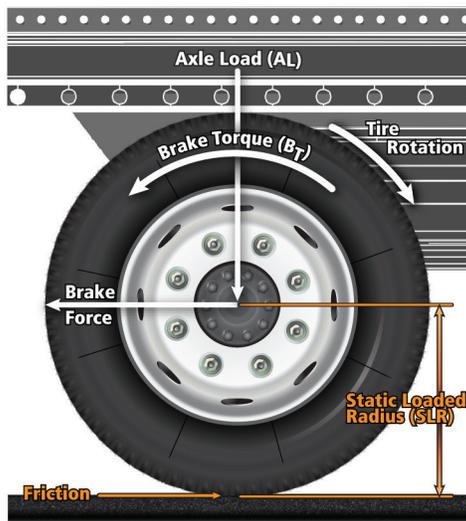
A foundation brake – drum or disc – with excess brake capacity is more reliant on the vehicle's anti-lock braking system (ABS), which negatively impacts overall stopping distance during a



panic stop. Understanding the relationship between brake types, anti-lock braking systems and stopping distance allows fleets to spec a more balanced, complete braking system, which can also have additional service life benefits for the vehicle's wheel ends.

The Dynamics of Stopping

Consider the basics of how a fully loaded North American tractor-trailer combination reacts during a braking event. The diagram above illustrates typical axle loads while the vehicle is at rest and during a high deceleration braking event. During panic stops, the load shifts from the trailer axles to the drive and steer axles. The harder the stop, the more the load transfers from the rear of the vehicle to the front, which affects the available tire gripping force. (Please refer to the diagram on Page 2.)



When brake torque (B_T) is greater than $(\mu) \times (A_L) \times (\text{tire SLR})$, wheel lock-up will occur.

μ = road friction coefficient
 A_L = axle vertical load during braking

For instance, during a 60 mph panic stop, the axle load (A_L) on a typical North American tandem trailer is reduced by 16% per axle while the tractor's steer axle experiences a 158% increase in load compared to its resting state. The reduction in trailer tire-to-ground grip can be exaggerated by road conditions (reduction in road surface friction (μ)), or a decrease in the vehicle's weight (unloaded vs. loaded). In both cases, the tire-to-ground grip will noticeably change. Taken further, during a high deceleration event, the wheels will lock up sooner causing the tires to slide.

Sliding tires can have serious negative consequences, especially when it comes to vehicle stability. To overcome this, the anti-lock braking system was created.

Anti-Lock Braking Systems & Stopping Distance

Anti-lock braking systems (ABS) are federally mandated for tractors and trailers in the United States and Canada. In essence, an ABS is a control system that is designed to minimize

vehicle lane departure by momentarily reducing the amount of air pressure available to the service brakes allowing the tires that are approaching sliding to begin rolling again. **While ABS provides critical performance benefits for the driver, it does so by lengthening the overall stopping distance.**

In general, ABS cycling may reduce the stopping effectiveness of the affected wheel end(s) by up to 20% compared to what could be obtained if the brake torque was held at the point where the tire approaches slip. The optimum system brakes a rolling tire near its slipping point.

Excess brake capacity can lead to longer average stopping distances because the ABS becomes more active in order to manage potential vehicle instability. **Sizing a brake to not significantly exceed the available tire gripping force on a typical road with a fully loaded trailer is therefore a good design target.**

“ABS ‘helps eliminate wheel lockup and prevent skidding, which helps drivers maintain control during stops on low-traction surfaces and in emergency stopping situations.’”

—Commercial Vehicle Safety Alliance

Performance Characteristics: Disc vs. Drum

Drum Brakes

Foundation brake design is a key factor that affects both component wear and stopping distance. This can best be understood when comparing the design differences of drum and disc brakes for different axle load ratings. S-cam brakes are self-energizing brakes, meaning the curved drum drags the curved shoe and tries to pivot it about the anchor pin resulting in a disproportionate increase of output force. This geometry allows a drum brake to be designed with lower lining friction levels.



23K drum brake linings operate better at higher temperatures because the lining rubs more aggressively against the drum

For the classic 20,000-lb. (20K) gross axle weight rating (GAWR), both 16.5-in. x 7-in. and 16.5 in. x 8.625-in. brakes have adequate surface area and thermal mass to keep the lining quiet and provide satisfactory wear while also meeting the brake load testing requirements as outlined by Federal Motor Vehicle Safety Standards FMVSS-121 or Canadian Motor Vehicle Safety Standards CMVSS-121.

Certifying S-cam drum brakes at a higher level, such as 23,000-lb. (23K) GAWR, requires a higher lining friction level to allow the same size brake absorb higher energy levels. To generalize, more abrasive material is added to a base 20,000-lb. (20K) GAWR formula to boost its friction level so it can provide an effective grip at the higher operating temperatures. The trade-off in obtaining the higher capacity rating, however, is reduced lining and drum life when compared to the 20,000-lb. GAWR-rated material.

If the specified friction level is higher than what is needed, noise and brake chatter can occur because the self-energizing effect of the S-cam brake will be overly aggressive; therefore, care must be exercised to specify the optimum friction level on S-cam drum brakes.

Disc brakes

Conversely, disc brakes are not self-energizing. They work by compressing two semi-metallic pads against a flat rotor. Because of the flat contact with the rotor, a more brittle, resin-reduced semi-metallic air disc pad formulation can be utilized successfully, whereas drum brake geometry makes it difficult to optimize performance with this type of material. Also, because flat pads rub against a flat rotor, noise is easier to control when compared to a drum brake.

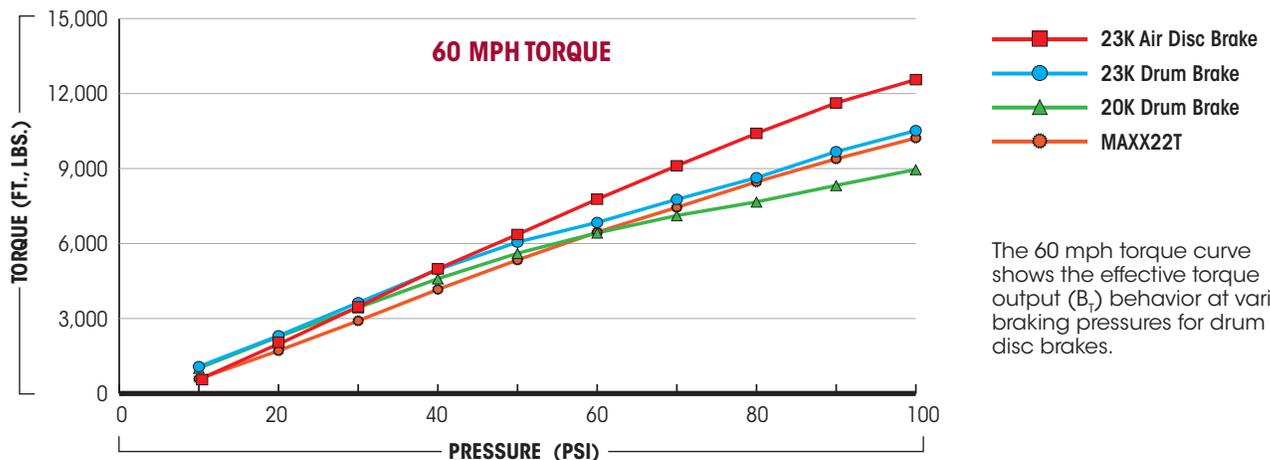
Rotors have less mass than brake drums, so they operate at higher temperatures for the same type of stop. Air disc semi-metallic pad materials are designed to operate best at these warmer temperatures and use a film transfer layer method of friction coupling, unlike classic drum brake materials.

The warmer operating temperature of the rotor allows the semi-metallic pad to build a layer of film on the rotor face. Once this film is established, the material transfers back and forth between the rotor and the pad during braking. This film transfer layer method of friction coupling is what prolongs pad and rotor life. This phenomenon also keeps the friction couple constant, enabling superior high temperature wear resistance while also allowing the brake to retain a stable torque level as the brake temperature rises.



Pads and rotor are in compression making it a good application for semi-metallic friction material.

Air Disc vs. Drum for Different Axle Load Cases



The 60 mph torque curve shows the effective torque output (B_r) behavior at various braking pressures for drum and disc brakes.

Cold Brake Torque

In addition to differences in thermal characteristics and lining formulations, dissimilarities exist in the torque output between drum and disc brakes. The diagram above illustrates stopping events performed when the brakes were initially engaged at typical on-highway operating temperatures. The air disc brake torque curves display a proportional torque to air pressure

relationship, as air disc brakes do not self-energize. In contrast, the drum brakes are aggressive (or quick to activate) at low pressures and tail off (or demonstrate in-stop fade) at high pressure.

Striking a balance between the proper brake torque over a broad range of operating temperatures, while achieving the best component wear for both the tractor and the trailer, can be a challenge.

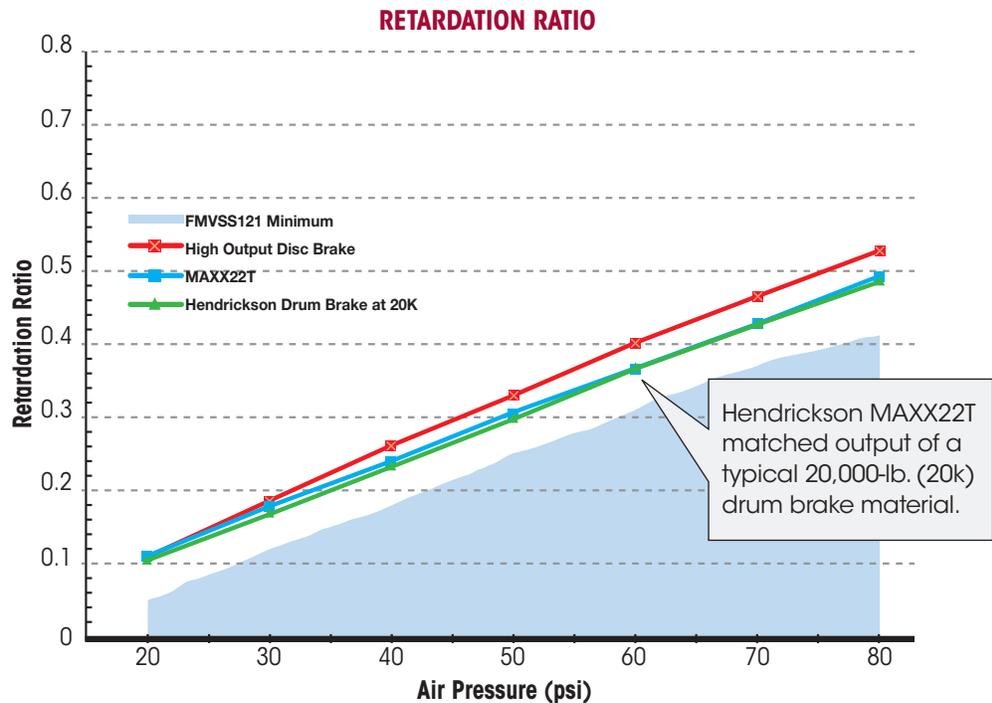
How MAXX22™ Is Optimal

Creating an air disc brake torque characteristic similar to or greater than a 23K drum brake can create a thermal imbalance for the combination vehicle in some conditions. An aggressive air disc-braked trailer can pull extra heat into the trailer brakes if combined with a drum-braked tractor because the drum brake tractor brakes fade as operating temperatures increase, and the air disc brakes do not. This can lead to excessive thermal stress in the brake rotors, requiring a more complex solution that can drive up acquisition costs, maintenance costs or weight of the braking system.

The Hendrickson MAXX22T air disc brake was created to be an optimized solution for trailer applications to meet the unique demands of the North American marketplace. This system is compatible with tractors that are either drum brake- or air disc brake-equipped and addresses the aforementioned concerns in the following ways:

1. Hendrickson MAXX22T maximizes the stopping ability of the classic 80,000-lb. tractor-trailer for real-world road conditions by **optimizing the size of the trailer air disc brake to match the vehicle's energy absorption needs** while making it less reliant on ABS to manage instability, which reduces stopping distance

2. Hendrickson MAXX22T produces the optimum amount of high-speed torque in addition to meeting FMVSS-121 energy standards. This means **MAXX22T maintains excellent**



Retardation ratio is a measure of the brakes' actual torque output divided by its theoretical output for a given tire size. FMVSS-121 only defines a minimum threshold. A value too large can contribute to a higher frequency of ABS related events. Hendrickson MAXX22T matched output of a typical 20,000-lb (20k) drum brake material

brake balance between tractor and trailer in normal operation when pulled by either a drum- or air disc- braked tractor. This engineering design provides better protection for the trailer rotors and allows for more optimal pad and rotor life compared to today's European style disc brake.

3. Hendrickson MAXX22T provides superior hot brake, high speed stopping ability. The brake rotor and caliper were designed to have thermal capacity for applications requiring extra load carrying capacity. By specifying the tire's static loaded radius (SLR) and taking advantage of the linear torque curve inherent to disc brakes, **MAXX22T can be rated up to 23,000-lb. (23K) GAWR without sacrificing tractor-trailer balance.** In turn, drum brakes generally require more aggressive lining materials to reach the higher GAWR, which results in a reduction in wear component life.

4. Hendrickson MAXX22T was right-sized for cold brake torque output to avoid overpowering today's empty, lightweight trailers. **MAXX22T was intended to have a slower increase of low-pressure torque than an S-cam drum brake which means drivers may report that the brakes are less sensitive or "touchy" when the trailer is empty.**

5. Hendrickson MAXX22T meets the durability and reliability requirements for the North American marketplace. In addition to brake size, considerations were taken in the design of MAXX22T with regards to corrosion protection, ease of maintenance and reliability. For instance, the MAXX series of calipers **feature WABCO's field proven bi-directional adjuster. This mechanism is designed to adjust running clearance in both directions minimizing the opportunity for hot running brakes** – a key performance consideration for any brake design.



Hendrickson's Brake Application guide, L809, aids in the selection of the proper brake and associated tires for the specific application. Visit www.hendrickson-intl.com/L809 for more information.

Conclusion

When placed in the correct operating environment, air disc brakes can be used successfully on today's modern commercial vehicles. Sizing the brake to meet the specific load carrying requirements of the trailer can improve the vehicle's average stopping distances while making the initial brake application less sensitive during normal applications. Distributing the work properly between the tractor and trailer can minimize thermal overload of the trailer brakes making a more robust wheel end that can result in longer service intervals of the brake's wear components.

By gaining a deeper understanding of the operating principles of both drum and disc brake designs, fleet managers are empowered to make more informed decisions when it comes to specifying equipment.

As the largest drum brake supplier to the NAFTA OEM trailer market, Hendrickson's experienced brake engineers understand the fundamental characteristics of both drum and air disc brake designs. They are well-versed on the features and benefits of each brake type and can assist in providing application advice for a variety of operating environments.

For more information on the features and benefits of the Hendrickson MAXX22T air disc brake system, visit www.MAXX22T.com.



ABOUT HENDRICKSON

Hendrickson was founded in 1913 and revolutionized the heavy-duty commercial vehicle industry in 1926 when the company introduced its first tandem walking-beam suspension. After more than 100 years, suspension technology and product innovation remain a focal point for Hendrickson. Decades of engineering innovation and dedication to quality has established the company as a global leader in new suspension systems and spring technology to the medium- and heavy-duty commercial vehicle industry. Ride performance, reliability and weight optimization are key attributes of all Hendrickson suspension systems and spring products.

Today, Hendrickson continues to lead the industry with innovations in exclusive process and materials technology, as well as advanced lightweight designs. With experience, expertise and vision, Hendrickson continues to redefine leaf spring and suspension engineering for medium- and heavy-duty commercial vehicle applications around the world. For example, as a leader in the production of Class 5-8 truck springs, Hendrickson continues to improve spring design and performance by operating one of the largest laboratories in North America dedicated to spring research and development.