HENDRICKSON

The World Rides On Us®

THE EVOLUTION OF TRAILER SUSPENSION DAMPING: A GUIDE TO BEST PRACTICES

The noticeable ride benefits of suspension damping devices also bring maintenance challenges for fleets. Educate yourself on the evolution of damping methods to better manage long-term costs.

HENDRICKSON
Trailer Commercial Vehicle Systems

All vehicles, passenger or commercial, are designed with damping in mind when it comes to the suspension. The primary goal of a suspension system is to carry the load from the vehicle while providing compliance between the sprung mass (chassis, trailer body, etc.) and the unsprung mass (the suspension, tires, wheels, brakes, etc). Damping devices, such as shock absorbers, are designed to add comfort and control by resisting the motion of the suspension. Without damping forces, a vehicle would have a tendency to bounce at its natural, or resonant, frequency. But over the service life of the vehicle, most suspension damping devices result in a compromise of either ride quality or added component maintenance. In the commercial trailer industry, managing issues like driver comfort, cargo protection, vehicle safety and government compliance can be a complicated balancing act. Understanding the fundamentals of damping enables fleets to better manage long-term maintenance and operation costs while keeping ride quality and driver satisfaction high.

What Is Damping and Why Do I Need It?

Damping describes the process of absorbing energy of road inputs that are transmitted through the suspension system. Suspension damping reduces the number and intensity of these inputs to the vehicle thereby helping to prolong the life of the vehicle and its components. In turn, this helps reduce overall operating and maintenance costs. In further detail, trailer suspension damping:

1. Results in fewer vibration inputs to the sprung mass of the trailer body. Reducing vibration helps extend the life of multiple trailer components, including door hinges, door seals, light fixtures and trailer fasteners. Protecting the trailer in this fashion extends the time between maintenance intervals and replacement cycles.

2. Reduces the amount of energy that is transmitted from the road to the cargo, providing better protection for the trailer's cargo, which can improve ROI and shipper satisfaction.

3. Enables the tires to maintain more consistent contact pressure relative to the road. Consistent tire contact pressure helps the tire wear more evenly, increasing the tire's service life.

4. Provides a more comfortable ride for enhanced driver satisfaction.

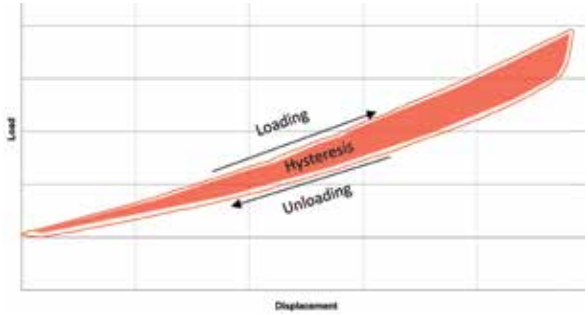
The Evolution of Trailer Suspension Damping

MULTI-LEAF SPRINGS

Some of the earliest commercial trailer suspensions used a multi-leaf spring design. The origins of this design date back to the middle ages and variations continue to be used on some commercial trailer applications today.

Multi-Leaf Spring Design

While not their primary function, multi-leaf springs do provide some suspension damping through interleaf friction — the movement of one spring leaf relative to the other. Leaf springs deflect when the vehicle travels over bumps or other irregularities in the road. The energy absorbed within the spring pack during these events is eventually relieved as the spring returns to its initial position. This motion, however, is not well-controlled on multi-leaf designs due to varying levels of hysteresis, which can be caused by many different factors. Factors such as manufacturing variations, pressure disparities between the spring leaves, and interleaf friction can all play a role in the spring pack's hysteresis.



Hysteresis Chart

A leaf spring's interleaf friction is dependent upon u-bolt clamp load. Maintaining proper clamp requires regular re-torqueing of the u-bolts — a satisfactory solution, but burdensome and time-consuming maintenance routine. Additionally, when a leaf spring is replaced, the new spring's surface condition, thus damping capability, is different from the existing springs in the pack. These conditions described above, along with varying maintenance practices may result in different friction thresholds (i.e., the point at which one leaf moves relative to another, determined by static friction or "stiction"). This can produce dissimilar damping rates on the same vehicle. The lack of consistent damping from a multi-leaf spring design may adversely affect the suspension's ride quality and can increase the need for trailer component maintenance or replacement.

MONO-LEAF SPRINGS

One approach to addressing the inconsistent damping rates of a multi-leaf spring suspension is the mono-leaf, or single-leaf, suspension. On one hand, mono-leaf designs eliminate the potential for manufacturing variations and variables that can affect damping characteristics like hysteresis. On the other hand, mono-leaf designs rely on the addition of other components such as shock absorbers or external suspension bump stops to perform the

damping function. While these components typically improve the suspension's ability to provide more consistent damping, they do so with a trade-off of time and money. These parts must be monitored, maintained and eventually replaced to sustain a desirable level of damping control. As these components deteriorate and are replaced at different intervals, variations in damping rates can occur.

Mono-Leaf Spring Design

AIR SUSPENSIONS

Trailer air suspensions offer yet another approach to suspension damping. Air suspensions use air springs instead of leaf springs as an interface between the axles and the trailer. The air springs act as trailer isolators, reducing the number of road inputs that are transmitted into the trailer while providing many of the same benefits mentioned with the mono-leaf design. Traditionally, the air spring's main role has been to react to vertical loads and maintain the suspension's (and thus trailer's) static height. Typically, air suspensions still require damping through other components such as shock absorbers to perform this function.

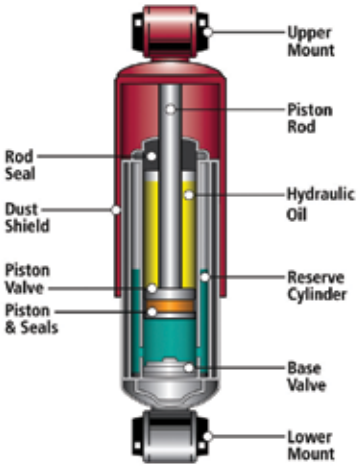
INTRAAX® Integrated Air Suspension System

Shock Absorbers

Shock absorbers (or more accurately, shock dampers) have evolved into a highly effective method for providing trailer suspension damping. While major improvements have been made to accomplish these more effective designs, there are still some unavoidable challenges associated with shock absorbers.

WHAT IS A SHOCK ABSORBER EXACTLY?

Modern shock absorbers can be described as highly specialized hydraulic cylinders. Instead of capturing hydraulic fluid to push a piston up or down, hydraulic shock absorbers are designed to control the motion of the piston through viscous damping by allowing hydraulic fluid to pass through a set of orifices and check valves. Controlling the fluid flow converts the energy from the motion of the shock absorber (and the suspension it is attached to) into heat, which is dissipated to the atmosphere through the body of the shock.



Anatomy of a Shock Absorber

COMMON CONCERNS

Oil Levels and Temperature

The amount of oil contained within a shock is crucial to maintaining its basic damping function. Too little oil can reduce the ability to absorb and transfer the heat generated from the suspension movement, leading to increased oil temperature. Too much heat can change the properties of the oil, which may affect its flow through the internal orifices, further limiting its ability to provide suspension damping. If the oil level becomes low enough, damping could become non-existent.

Movement

Since the shock absorber is typically attached directly to the suspension, it is constantly moving as the trailer is in operation. The movement causes internal and external component wear that will deteriorate the shock absorber's ability to provide suspension damping over time.

External Seal

Shock absorbers feature a seal that is designed to keep hydraulic fluid in the shock and to prevent contaminant ingress. The constant movement of the shock absorber requires the shock seal to contend with high wear inputs and high temperatures from friction while still performing its function of keeping fluid in and contaminants out. Shock seals are designed to allow a slight amount of hydraulic fluid to pass by the seal during its operation. The fluid acts as a lubricant to help extend the life of the seal. When an excessive amount of fluid bypasses the seal, it can be an indicator that the seal is worn or damaged and that the shock absorber should be replaced.

LEAKING VS. MISTING: HOW MUCH FLUID IS TOO MUCH?

MISTING **LEAKING**

A leaking shock absorber usually means it should be replaced, while a shock with a lightly misted outer coating can simply indicate normal operation.

The problem for the mechanic or the roadside inspector is ascertaining how much external fluid is too much. A shock with a lightly misted outer coating of hydraulic fluid can simply indicate normal operation, but a shock with runs of oil on the outer body usually means it should be replaced. For some, any external oil can be interpreted as a problem indicator, resulting in a good shock being unnecessarily replaced or a citation from a roadside inspector.

RATES OF DAMPING LOSS, AND SIGNS OF WEAR AND TEAR

Shock absorbers provide a high level of consistent suspension damping when new. Due to the inputs described above, however, shock absorbers wear at different rates as they age. This could lead to a loss of suspension damping with little outward indication of a problem.

When a shock is functioning correctly, it is generating heat and transferring that heat to the atmosphere. The simplest way to determine if a shock absorber is doing this job is to touch

the outside of the shock body immediately after it has been in operation. If it is warmer than the rest of the suspension, it is providing some amount of damping. Unfortunately, this type of check does not communicate a definitive level of damping — it only indicates that some amount of damping is occurring. Additionally, this type of check is subjective and is not always easy to schedule as part of the trailer maintenance routine.

Age-Old Problem Solved

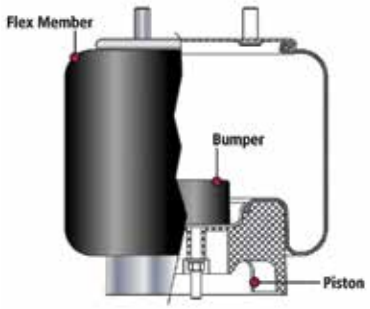
Hendrickson Trailer Commercial Vehicle Systems addresses the inherent shortcomings of previous damping control methods with a revolutionary approach — ZMD® ZERO MAINTENANCE DAMPING®, an alternative solution for fleets seeking reduced maintenance and improved ride quality.

Hendrickson's ZMD system eliminates the need for an external damping component such as a shock absorber. Instead, the suspension damping function has been incorporated into the suspension air springs. ZMD eliminates the worry of inconsistent damping while maintaining the superior ride quality and performance of Hendrickson air suspensions.

ZMD's unique, patented air spring design provides suspension damping and trailer isolation all in one package without adding additional components to the air spring.

HOW DOES ZMD WORK AND WHY DOES IT REQUIRE LESS MAINTENANCE THAN OTHER DAMPING SYSTEMS?

Commercial trailer air suspension air springs are typically composed of three major components:



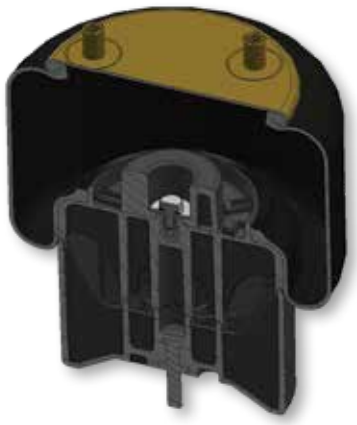
Anatomy of a Standard Air Spring

1. **The upper flex member:** On traditional trailer air springs, the upper flex member is sealed and pressurized in order to support the trailer. As the axle moves up and down, the air within the flex member is compressed or expanded. The compressible nature of an inflated flex member absorbs the axle movement, isolating the trailer from road inputs.
2. **The lower piston:** The lower air spring piston is typically hollow and open to the atmosphere. Its function is to support the flex member as the suspension moves up and down. It also serves as a mounting surface for the internal air spring bumper.
3. **An internal air spring bumper:** The bumper prevents the air spring from collapsing too far and damaging the flex member or allowing excessive axle travel.

Unlike a standard air spring, the ZMD air spring's piston is sealed and pressurized. The ZMD air spring flex member and piston are connected so that air can flow between the two. As the axle moves up and down, pressurized air is exchanged between the flex member and the piston. By controlling the flow of air between these two components, the ZMD air spring is able to provide consistent and continuous suspension damping. No additional components are added to the air spring, so no new components are subject to wear.

Eliminating the main wear item not only removes the underlying causes for damping degradation but also its subsequent maintenance requirements. As a result, the ZMD system provides the same, consistent level of suspension damping for the entire life of the air spring. In addition, ZMD eliminates the possibility of leaking fluids, which could potentially sideline a trailer at an inspection.

ZMD's unique approach to suspension damping helps address one of the biggest issues facing the commercial vehicle industry today - drivers. Unsolicited comments from tractor/trailer operators report an improved driving experience. Once they've tried it, drivers usually request trailers with ZMD over conventional air suspension systems.



Anatomy of a ZMD® Air Spring

Hendrickson's ZERO MAINTENANCE DAMPING system finally addresses the problems designers have struggled with since the invention of the suspension. It solves the age-old problems of varying damping levels, component evaluation, and replacement and roadside inspection violations of previous damping control methods. ZMD represents the next evolution of suspension damping design with a simplified, low-maintenance solution.

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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.

Actual product performance may vary depending upon vehicle configuration, operation, service and other factors.
All applications must comply with applicable Hendrickson specifications and must be approved by the respective vehicle manufacturer with the vehicle in its original, as-built configuration.
Contact Hendrickson for additional details regarding specifications, applications, capacities, and operation, service and maintenance instructions.

*Call Hendrickson at **866.RIDEAIR (743.3247)** for additional information.*

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