Dorman Training Center Presents:

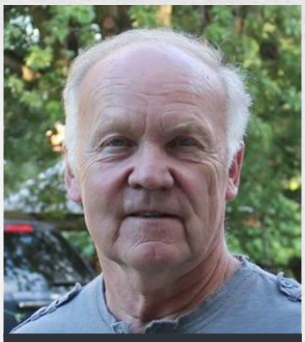
CMV SUSPENSIONS A-Z

2025

1

Your Instructor For This Webinar

Swede is the owner of a repair shop and is an ATTP Master Instructor. He's the author of "Medium/Heavy Duty Truck Electricity and Electronics" and has developed and presented training courses that specialize in brakes, electrical systems and other automotive repair topics.



Swede Oun

swede@oktruckrepairwny.com

2

2

What Will Be Covered:

Instructions for this Webinar:

- This webinar will be approx. 1+ hour long
- All slides that are presented are in your handout and are numbered
- Have a pen or pencil and paper for notes
- Questions can be asked at anytime

01 CMV Suspension Overview

02 Leaf Spring Systems

03 Air Spring

04 Case Studies

05 System Descriptions

06 System Operation

Suspensions

This is a new recyclable spring developed by a new suspension manufacturer. They are looking for distributors. If interested, see me after training.

Chances are good for their products to meet farm and farm covered vehicle exemptions for transporting their products.

Suspensions

Installation is simple, requiring minimum tools.

5

Suspensions

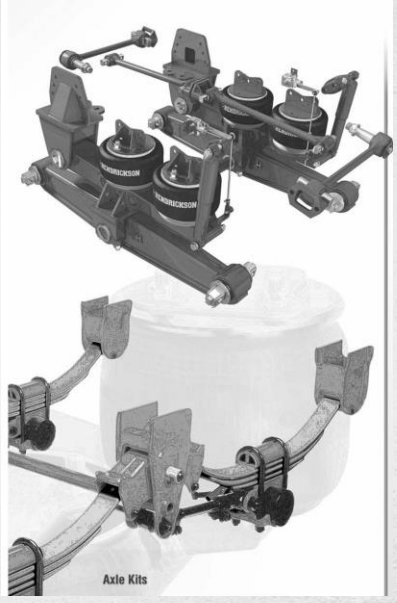
Simple Description

- **By supporting the frame, the suspension acts as the intermediary between the axles and the frame.**

Note: The suspension is expected to support the heaviest load the vehicle is designed for.

However, this could lead to a harsh ride when empty. A good suspension needs to perform well whether loaded or unloaded.

"It's a Balancing Act"



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Suspensions

- **The primary purpose of a suspension system is to support the vehicles weight with and without a load.**
- **The suspension system also stabilizes the vehicle when traveling over various terrain encountered when traveling.**
- **The suspension system is also used to maintain proper axle spacing and alignment.**
- **The suspension system must also be capable of absorbing the chassis from road shock.**

NOTE: This only works if the correct load range is maintained.

Excessive loads can damage the suspension system and its components and other components such as the frame, tires and axles.

Suspensions

The most common suspension systems used on todays trucks are:

- **Spring**
- **Equalizing beam**
- **Air bag**

Springs are further categorized:

- **Constant rate**
- **Progressive or vari-rate**
- **Auxiliary**

Suspensions

Leaf Spring Suspensions

- **These range from a single leaf (steel plate) to a stack of leaf's (steel plates). "Dating back to the days of horse and buggy".**
- **These leaf's are manufactured from "spring steel"(an alloy steel that has been tempered). Ideal for fabricating knives etc. by a good blacksmith.**
- **The spring steel allows for flexing without permanently deforming.**

Suspensions "Leaf Spring Suspensions"

Provisions For Deforming

- **As a load is applied to a spring pack, it begins to deflect.**
- **By clamping the leaf's together, movement (due to deflection) cause-and-effect overcome friction between the cause-and-effect. This provides a self dampening characteristic to the spring pack.**
- **Dampening is important to limit "oscillations" after a spring compresses.**

Note: The "center bolt" that clamps the leaf's is crucial in maintaining the self-dampening ability of the spring assembly.

- **Maintaining the "center bolt" integrity is very important.**
- **A broken center bolt can create a number of cause – and - effect issues.**

Suspensions "Leaf Spring Suspensions"

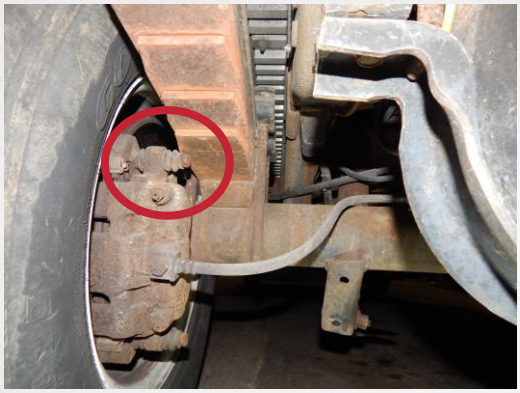
A good analogy of "dampening suspension" is a shock absorber used to dampen suspension oscillations.

- **Follow a car with bad shocks and chances are good you can see the effects of a bad shock(s).**
- **Multi leaf springs can be just as effective as a shock absorber in dampening suspension oscillations.**

11

11

Suspensions "Leaf Spring Suspensions"



If this vehicle came to your shop for an annual inspection, would you be looking for defects like this?
Would you pass it as meeting inspection requirements?

12

12

Suspensions

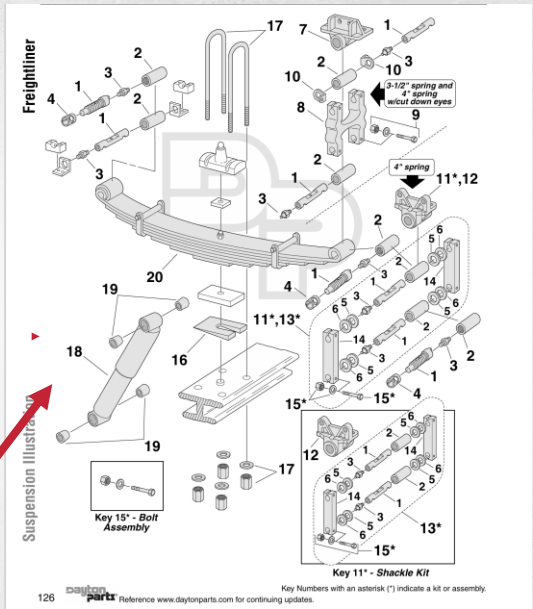
Does anything stick out in this picture?

Constant Rate Springs

- These springs have a constant rate of deflection. For example:
- If 500 lbs. deflects the spring assembly 1 inch, 1000 lbs. would deflect the same spring assembly 2 inches.
- A constant rate spring is mounted to the axle with the front of the spring mounted to a stationary bracket and the rear end of the spring is mounted to a spring shackle.
- The shackle allows for variations in spring length during compression and rebound.

Suspensions

What are you thinking about when you see these parts?
Easy replacing?
Easy just replacing the bushings?
Lots of parts involved in a spring suspension.



Suspensions

Progressive (Vari-Rate) Springs

- These springs are a leaf type spring assemblies with a variable deflection rate obtained by varying the effective length of the spring assembly
- A cam type bracket is used.
- As the spring assembly deflects, the point of contact on the bracket moves toward the center of the spring assembly shortening the effective length.

Suspensions

Not all springs sit on top of an axle.

VEHICLE OUT-OF-SERVICE CRITERIA

What is a main leaf in a leaf spring assembly? **If it extends, at both ends, to or beyond:**

a. **The load bearing surface of a spring hanger or equalizer.**
b. **The spring end cap or insulator box mounted on the axle.**
c. **A spring eye, further: Any leaf or helper spring assembly is a helper main leaf if it extends, at both ends, to or beyond the load bearing surface of its contact pad, hanger, or equalizer.**

4 Main Leafs.

17

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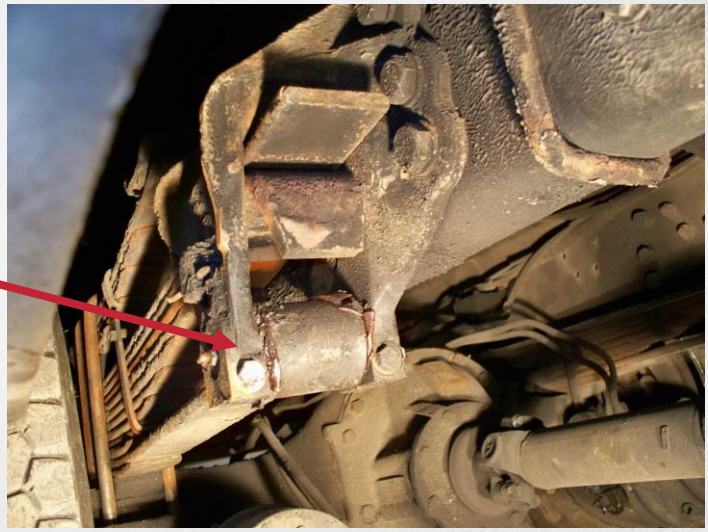
17

Suspensions

Torque leaf.
Get in the habit of checking pin and bushing.



18

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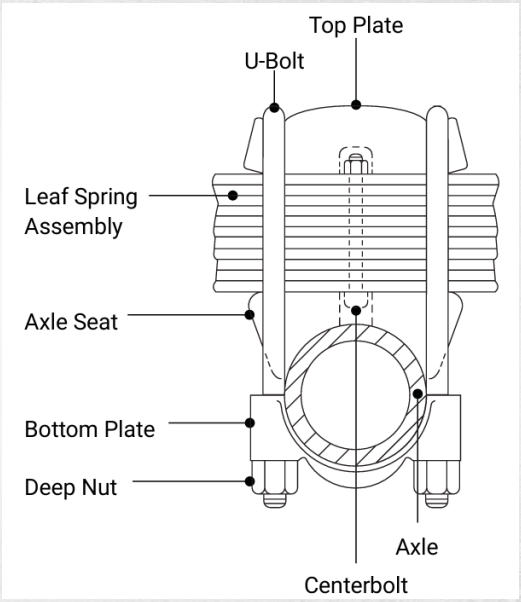
U-Bolts "Tech Essentials"

www.daytonparts.com

What does a U-Bolt do?

- **The U-Bolt provides the force required to clamp the leaf spring and related components firmly together.**
- **A properly installed U-Bolt eliminates any flexing of the leaf spring in the area between the U-bolts.**

Note: This is critical since the hole for the center bolt in each leaf acts as a stress concentration which would lead to rapid leaf breakage if spring flexing was not totally eliminated by the U-Bolt clamping force.



19

U-Bolts "Tech Essentials" cont.

- **By clamping the spring to the axle seat, the *horizontal forces* acting on the center bolt are greatly reduced which in turn prevents shearing of the center bolt.**
- **Finally, proper clamping of the spring by the U-bolts provide the desired spring stiffness and contributes to maintaining the vehicle ride height and handling characteristics as originally specified for the vehicle.**

VERY IMPORTANT: Virtually, all leaf spring failures through the center hole are caused by inadequate U-Bolt clamping.

Look for signs of movement within the area between the U-Bolts. Worn or polished surfaces on the axle seats or top plates are indicators of unwanted movement that has occurred. Replace any damaged components.

20

Suspensions

Part 393.207(a) Axle positioning parts broken, missing, resulting in axle to shift. Part393.207(c) Broken leaf in spring assy. Part 392.7 Failing to perform a proper pre-trip. Part396.7 Unsafe operation forbidden.

Note: Top plate missing, axle has shifted a couple of inches.

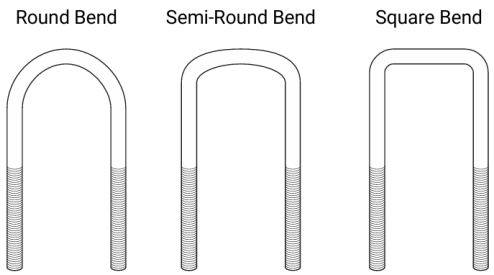
21

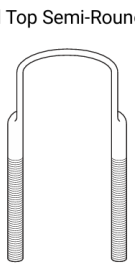
U-Bolts “Tech Essentials”

Types of U-Bolts

Three basic types of bends are used on U-Bolts depending on the suspension design and the shape of the mating parts:

Additionally, each of these bend types may use forged material. This is used primarily where additional clearance is required between the U-Bolts and, for example, the frame.





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Dayton Parts, LLC

22

U-Bolts “Tech Essentials”

U-Bolt Do’s and Don’ts

DO NOT reuse U-Bolts

- **Used U-Bolts will have rusted and damaged threads from the previous installation.**
- **Previously torqued (used) U-bolt will suffer from distorted threads from the engagement of the deep nut. “Deep nuts should be tightened once and re-torqued”, never “loosened and retightened”.**
- **A used U-Bolt may have suffered from fatigue as well as excessive stress.**

Note: Trying to achieve proper clamping force will be hard to achieve with re-used U-Bolts.

U-Bolts “Tech Essentials”

U-Bolt Do’s and Don’ts

“RETORQUE THE U-Bolts”

Retighten U-Bolts after the first 500 to 1,000 miles.

When new or repaired springs wear in, a settling of the spring stack will occur. This can cause a reduction in U-Bolt clamping force.

Ideally. The retorquing should be done with the vehicle under load.

“Suggested” Torque for Grade 8 U-Bolts:

Size (Diameter x Thread)	Torque (ft. lbs.)
5/8 -18	170
3/4 -16	300
7/8 -14	480
1 -14	740
1 1/8 -14	1300

Air Bag (Spring) Suspensions

Air Bag (Spring) Suspensions

- This is a very popular suspension system used by heavy duty trucks and trailers.
- This system provides the ultimate smooth, shock and vibration ride.
- The air spring suspension system adjusts to load conditions automatically
- This allows a low-rate suspension with a light or no load and a high-rate suspension with heavier loads.
- To accomplish this, a height control (leveling valve) is utilized to automatically provide and maintain vehicle ride height.
- This valve is sensitive to frame height and will provide automatic filling or exhausting of the air springs (bags) to maintain the vehicles level.
- The lever arm on the valve has a neutral position that serves to automatically return the valve to a closed position.

25

Air Bag (Spring) Suspensions

Case Study

Complaint: ABS light would come on occasion.

Codes where not typical ABS codes.

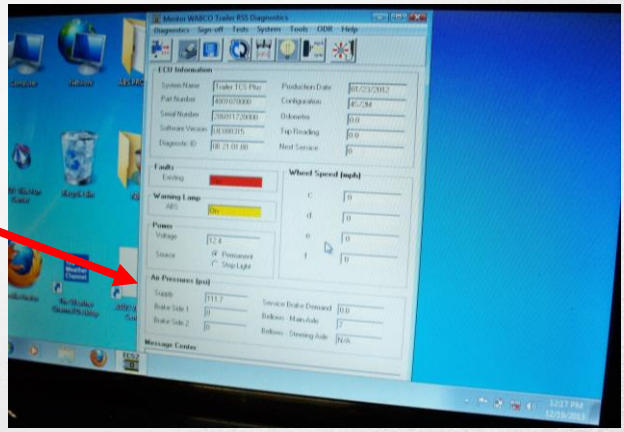
Stability type of codes.

26

Air Bag (Spring) Suspensions

Occasionally the ABS light comes on. Usually when empty. This is another Roll Support System. Where do you start?

Start with looking at suspension pressures and service brake pressure applications.



The reason we started to look at suspension is because driver said, "it usually happens when it is empty".

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27

Air Bag (Spring) Suspensions

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Air Bag (Spring) Suspensions

We checked and verified leveling valves where working and bags were getting right pressures. Also was air getting to module?
We used a blow gun also and monitored scan tool. No changes.
The fix was replacing this very expensive unit.

Air Bag (Spring) Suspensions

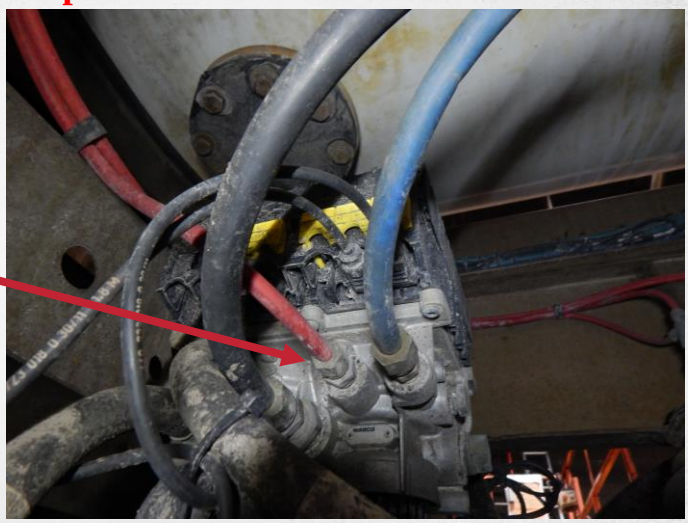
Air Bags

Module Assembly

Leveling Valve

Air Bag (Spring) Suspensions

Air line from Air Bag



31

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Suspensions

Rubber block style equalizer beam suspension

32

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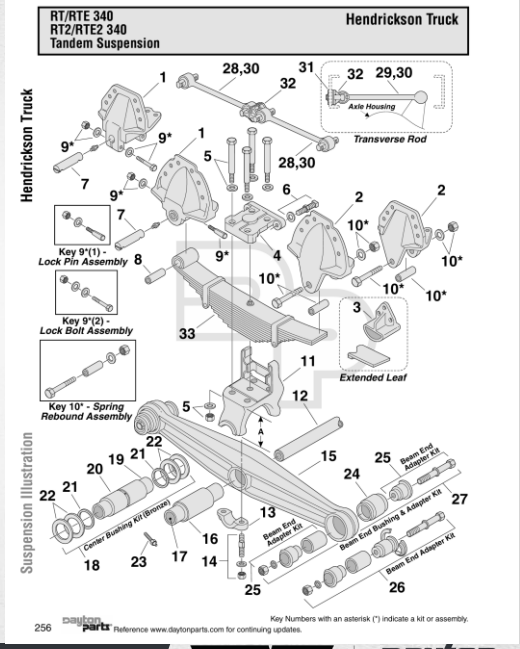
32

Suspensions "Equalizer Beam"

Pulling these beam end bushings can be a real pain. Tips from veteran Tech's can really help.

334-428

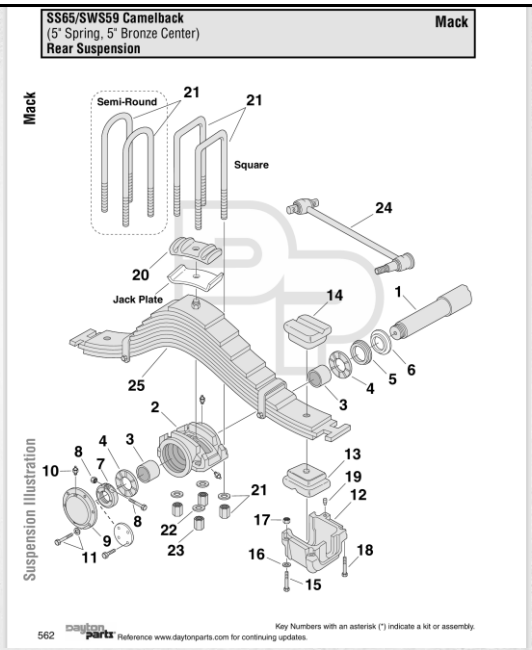
Bushing & Adapter Kit; Incl. 321-242 Bushing, 334-467 Adapter; Model RS 380/400/440/460



Suspensions Mack Camel Back

Don't take this spring job on, unless you know how to support it and have the proper tools.

"Torque Multiplier"



Suspensions

Shock Absorbers

- A hydraulic shock absorber is designed and used to dampen oscillations from road variations and shock.
- A piston and rod is enclosed inside a cylinder filled with oil.
- Typically, the shell is mounted on the axle while the piston rod assembly mounts to the frame.
- The piston contains valved metering orifices designed to allow oil to flow more easily to one side of the piston than the other side.
- This allows the shock absorber to compress more easily than it will extend.
- This ratio or rate is ideal for absorbing bumps in the road and controlling the rebound rate of the unsprung weight of the axle and wheel assemblies.

35

Suspensions

Note: some of the following info is courtesy of Dayton "Suspension Tech"

Shock Absorber "It's a relationship".

Shock absorbers play a crucial role in the suspension system, especially in vehicles equipped with air springs (bags). Shock absorbers are used to "dampen" "shocks", that occur between compression and rebounding with each impact.

Basically, the shock serves to return the spring to it' installed height quickly and keep the tire in contact with the road. Otherwise, each impact would cause a series of oscillations that could occur if the springs existed unchecked.

The goal is to always maintain contact between the tire and road.

Braking and the relationship of ABS comes to my mind.
See my ABS lunch and learns on how ABS works.

36

Suspensions

Shock failure is sometimes hard to diagnose, when it isn't broken or leaking. A Heat Test can be one way to determine a bad shock.

- **Drive the vehicle, preferably loaded, on a rough road for a minimum of 15 minutes.**
- **Lightly touch the shock absorber body below the dust cover.**
- **A warm shock absorber indicates it is working.**
- **A cold shock absorber should be replaced.**

An infra-red temperature gun works great.

37

37

Suspensions

38

38

Suspensions

39

39

Suspensions This is a regulatory reminder

- Leaf springs must not be cracked or broken
- Coil springs must not be cracked or broken
- Torsion bars must not be cracked or broken
- Air suspension must support the vehicle in a level position and must not leak

40

40

Suspensions

41

Suspensions

Why does this happen?
Maintenance is not rocket science.
However, proper maintenance (PM) is the most important task in our industry to keep CMV safe.
Maintenance takes the highest priority.

42

Suspensions

What type of a vehicle is this?

What are you seeing here?

43

Suspensions

A large P/U Dump Body.

This fits the violation description to a tee. Part393.207(a) " Any axle, axle housing, spring hanger(s), or other positioning part(s) cracked, broken, loose, or missing resulting in shifting of an axle from its normal position.

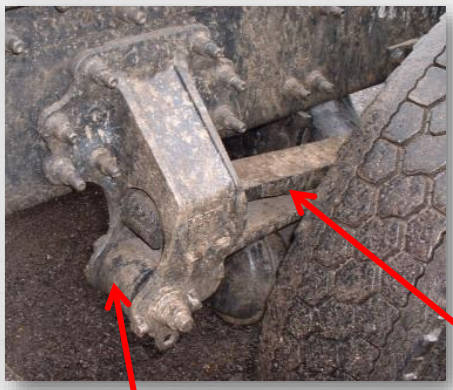
44

Suspensions

Part 393.207(c) Leaf spring assembly defective/missing.
NOTE: Includes whether one-fourth or more leaves, any leaf or portion of any leaf is missing or separated, or any main leaf is missing.

Suspensions

VEHICLE OUT-OF-SERVICE CRITERIA



Radius Rod Leaf

Load Bearing Leaf

The radius rod leaf, in springs having such a leaf, has the same function as the torque or radius components referenced in "Suspension-Torque, Radius, Tracking or Sway Bar Components" and should be treated as such component for purposes of out-of-service.
"As per CVSA"

Suspensions

VEHICLE OUT-OF-SERVICE CRITERIA

Inspection Item	Out-of-Service Criteria
SUSPENSIONS	(4) Coil spring broken. (393.207(d))
	(5) Rubber spring missing. (393.207(a))
	(6) One or more leaves displaced in a manner that could result in contact with tire, rim, brake drum, or frame. (393.207(c))
	(7) Broken torsion bar spring in torsion bar suspension. (393.207(e))
	(8) Deflated air suspension (one or more deflated air spring/bag). (393.207(f).

NOTE: All of these have a severity weight of "7" and driver responsibility "Y"

NOTE: There is also a (393.207(g)):No/defective air suspension exhaust control. This is severity weight "7". Driver responsibility "N".

Suspensions

Steerable lift axle.
It's a combination of and relationship with steering and suspension.
Many states have regulations and requirements for these systems.

Suspensions

VEHICLE OUT-OF-SERVICE CRITERIA

Preventable?

How many people in that organization didn't understand responsibilities?

Suspensions

How good is your visual inspection skills?

Suspensions

VEHICLE OUT-OF-SERVICE CRITERIA

Inspection Item | **Out-of-Service Criteria**

SUSPENSIONS c. **Composite Springs**

(1) Intersection cracks of any length. (393.207(c))

(2) Any crack that extends beyond ¾ the length of spring. (393.207(c))

NOTE: A crack is a separation in any axis which passes completely through the spring.

51

51

Suspensions

VEHICLE OUT-OF-SERVICE CRITERIA

Inspection Item | **Out-of-Service Criteria**

SUSPENSIONS d. **Torque, Radius, Tracking or Sway Bar Components**

Any part of a torque, radius, or tracking component assembly or any part used for attaching same to the vehicle frame or axle that is cracked, loose, broken, or missing (including spring leaves used as radius or torque rod, missing bushings but not loose bushings in torque, track rods or sway bars). (393.207(a))

What are we seeing here?

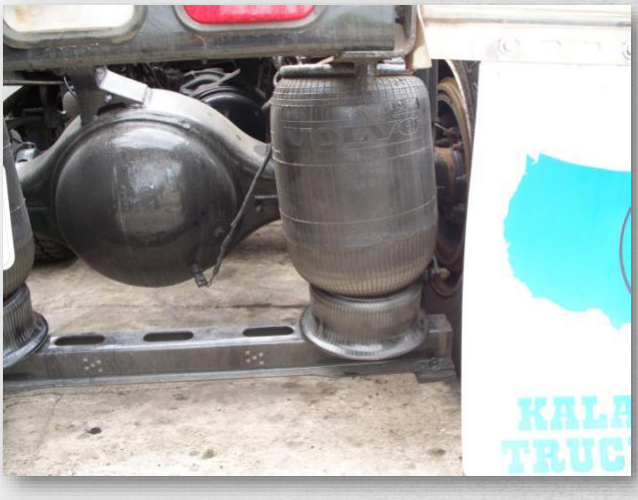
52

52

Suspensions

Case Study

- Owner bought used vehicle from out of state.
- Needed annual inspection to register in our state.
- First glance indicates an issue.
- Looking at bag, indicates overfill?
- Leveling valve issue?



Suspensions

Case Study

Look at hangers.

We wouldn't pass it unless those components got replaced.
Very sadly, the new owner had to threaten the out of state dealer with legal action to get it covered.
How many entities in the system should share the blame?

Suspensions

Case Study

Same vehicle.
Look at torque arm.
Look at driveshaft angle.
Yes!
Suspension play a crucial role in the complete vehicle dynamics.

We are a very regulated industry. The results of our actions can result in violations and possible accidents with real dire consequences.

55

Suspensions

"Height Control Valves" (Leveling Valves)

Purpose

- Height Control Valves (HCV) are used to automatically add and exhaust air from air suspension systems to maintain a constant static design ride height.
- HCV's (leveling valves) and the linkages are designed to maintain the vehicles "Ride Height" as loads increase and decrease.
- Correct installation is crucial to maintaining suspension and vehicle performance.
- For that reason, the OEM's specifications must be followed when installing an air control system.
- **Their specifications have to be used for valve locations and "ride height"**

Side Note: Many drivers complain about the ride performance when someone replaces a leveling valve. A driver has a good feel of what's under their seat.

56

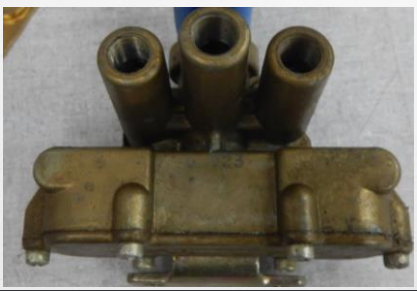
Suspensions "Height Control Valves" (Leveling Valves)

How it works

- A typical HCV has a lever rigidly connected to the axle assembly (usually the rear axle) by means of a linkage (flat or rod).
- The lever is used to control air into and out of the air springs.
- When the axle moves upward in relation to the chassis (frame) as when driving over a road bump, the lever is forced upward.
- The reverse happens when the axle goes into a pothole.
- **Moving the lever charges and discharges air to the air springs.**
- HCV's have a delay mechanism built into them to prevent rapid cycling.
- Typically, the valve has a neutral position, indicating the air suspension is properly inflated to the proper vehicle level. (No air passes through the valve).

Suspensions "Height Control Valves" (Leveling Valves)

- When the lever is moved off this neutral position, the valve meters or exhausts air from the air springs, depending whether the lever is moved up or down.
- When the vehicle is driven (normal road conditions), a hydraulic delay feature dampens the random inputs from normal road shock to keep the valve from rapid cycling between the opening and closing events.



Suspensions “Height Control Valves” (Leveling Valves)

Example of applying a load to the chassis (coupling a tractor to the trailer)

- The frame (tractors) lowers in relation to the axle(s).
- The HCV lever moves to open the valve, metering air to the air springs.
- The air passes through the valve (from supply) to charge the air springs and inflate them to raise the frame to resume its “SET” ride height. And neutralize the valve.

When uncoupling (dropping) the trailer

- The frame (tractors) rises in relation to the axles.
- This moves the control lever to an angle causing the valve to exhaust air until the frame resumes its set ride height again.

Suspensions “Height Control Valves” (Leveling Valves)

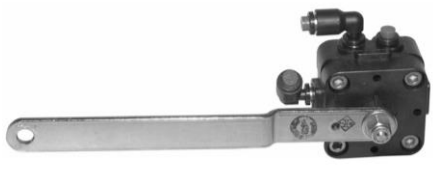
Pressure control

- Most air suspensions on trucks and trailers use a ***pressure regulator*** in the air circuit to regulate suspension air to a lower value than the chassis air.
- 90 PSI seems to be typical.
- These systems are usually combined also with a ***pressure protection valve*** to prevent loss of air pressure, required for braking, in the event of a serious suspension air loss.

334-1974

Height control valve, HCV w/integral dump - Hendrickson Trailer (OEM Ref.: VS-228)

334-2003



Height control valve, HCV assembly LH - AIRTEK (OEM Ref.: 59935-13)

Suspensions

"Height Control Valves" (Leveling Valves)

Air suspension systems can be more complicated when you get involved with piloted valves, brake isolation etc.

Component Photos

334-2033

Lift axle control, outside mount - fixed or steerable axles (OEM Ref.: HAC-USO)

334-2034-1 / 334-2034-2

Lift axle control, trailer; 334-2034-1 equalizing w/o brake isolation (OEM Ref.: AKAD2010-1)/334-2034-2 equalizing w brake isolation (OEM Ref.: AKAD2010-2); stainless enclosure (Hendrickson Trailer)

334-2077

3 Way Piloted Valve - Hendrickson Trailer Surelok (OEM Ref.: VS-23588)

334-2078

4 Way Push Pull Valve - Hendrickson Trailer Surelok (OEM Ref.: VS-14179)

1040 daytonparts **HCV Assembly** = HCV w/bracket / **HCV Kit** = HCV assembly and linkage
Reference www.daytonparts.com for continuing updates.

61

Suspensions

If you were an enforcement Officer, would you consider this a suspension violation or frame violation?

62

Suspensions

63

Suspensions

64

Suspensions

Least desired job.
That's why we are special.
We take on anything that is thrown at us.

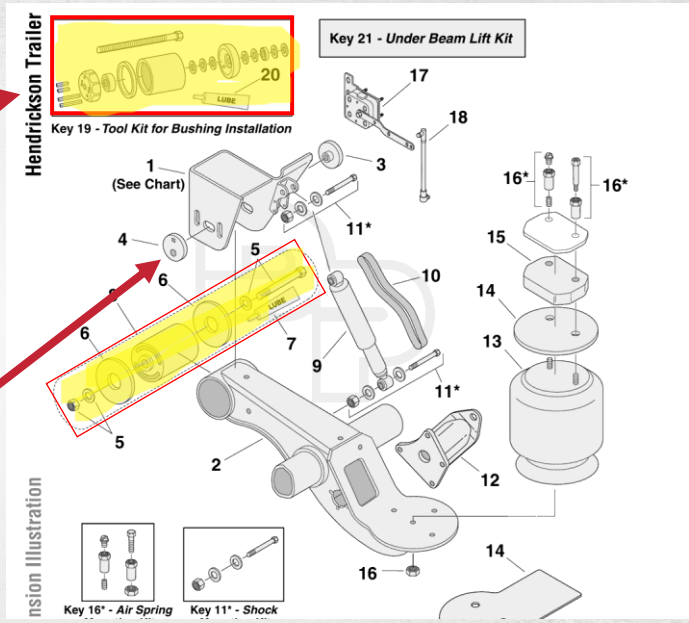
65

Air Bag (Spring) Suspensions

Tool Kit

Replacing the bushing can be labor intensive.
Don't attempt it unless you have the right tools.
RTFI. Aligning the new bushing (clocking it) Is crucial.
Torquing is very important.

Watch your alignment.



66

Suspensions

Before

67

Air Bag (Spring) Suspensions

After

68

Air Bag (Spring) Suspensions

334-1576

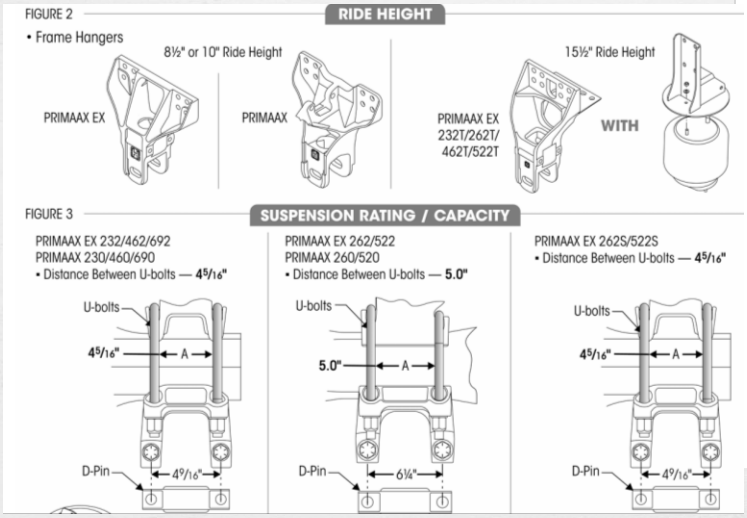
Service Kit, Pivot Bushing; QUIK-ALIGN®; All Ex. HT-Y Beam; Incl. Bushing, Pivot Bolt Kit & Spacers; Model HK/HS

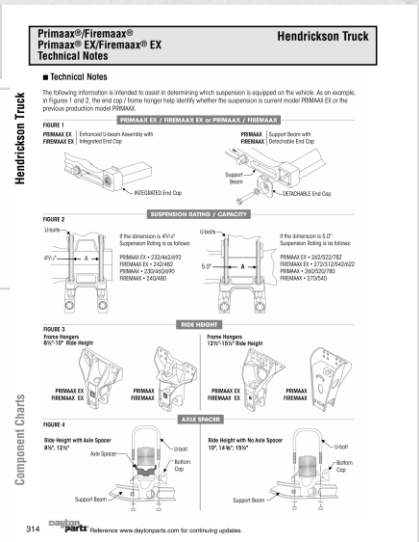
334-936

Tri-Functional® Bushing Installation Tool

DAYTON Suspension Tech Notes

Using right parts is critical. RTFI





Suspensions

The Real World

71

Suspensions

No matter how you look at it, it is still a suspension issue.

Of course, it falls under stupidity.

72

Suspensions

Suspensions

Suspensions

REJECT IF ANY SPRING IS

- Missing
- Noticeably Sagging
- Broken or Missing a Leaf or Part of a Leaf
- Composite Spring Cracked More Than ¾" In Any Direction
- Any Center Bolt is Broken
- Any Shackle is Excessively Worn or Loose
- Any Eye or Pin Bolts are Broken or Missing

Questions?

Thank You!

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77