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TMC
Technical &
Maintenance
Conference

Shock Absorbers

Presented by: Ian Thomson – BPW Transpec
: Stephen Cooper –Hendrickson Australia
: Barry Brookes – Toperformance (Koni)

TOPERFORMANCE PRODUCTS

KONI FACTORY DISTRIBUTOR

(FOR 31 YEARS)

OF CAR, TRUCK AND BUS AND RACING SHOCK ABSORBERS RANGE

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SHAW'S
ROAD
NV 14EL
TRAIN

Air suspension and shock absorbers

For Truck and Trailer air suspensions there are a wide variety of shock absorbers.

Each brand will have their own special characteristics and design features.

They are all intended to do the same general function which is to dampen suspension oscillation which is caused by bumps in the road.

Why do we need Shock Absorbers?

With out shock absorbers or some form of damping the motion from a bump or bumps would allow the axle/suspension/wheels and tyres to bounce along like a basketball.

With air suspension we dampen oscillation motion out with shock absorbers.

With a spring type suspension the oscillations are absorbed through friction and load transfer through some parts.

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Shock Absorbers

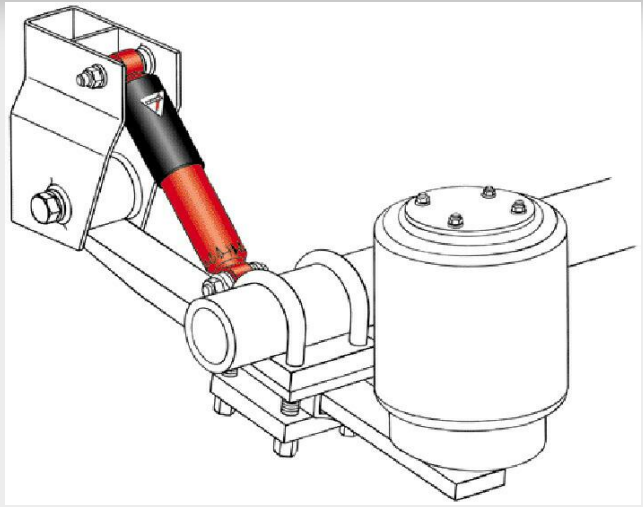
- Shock Absorbers improve vehicle handling
- Make the vehicle more stable
- Ensure best traction effort can be gained
- Ensure best grip cornering and braking
- Help protect freight from damage
- Reduce road damage / degradation

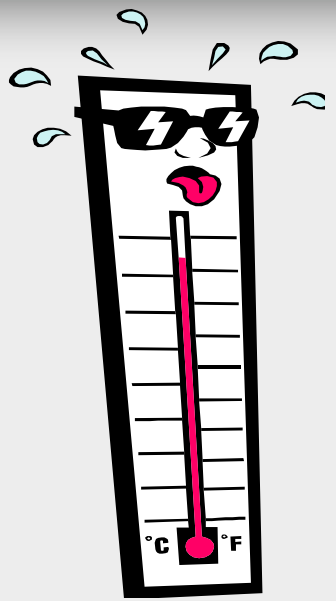
What does a shock absorber Do?

Why is that round tubular thing bolted to my suspension??

Suspension Movement = Energy

Maintenance Conference





SHOCK ABSORBER MOVEMENT CHANGES MECHANICAL ENERGY TO HEAT!!

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therefore:-

shock absorbers are

“HEAT EXCHANGERS”

also :-

shock absorbers are

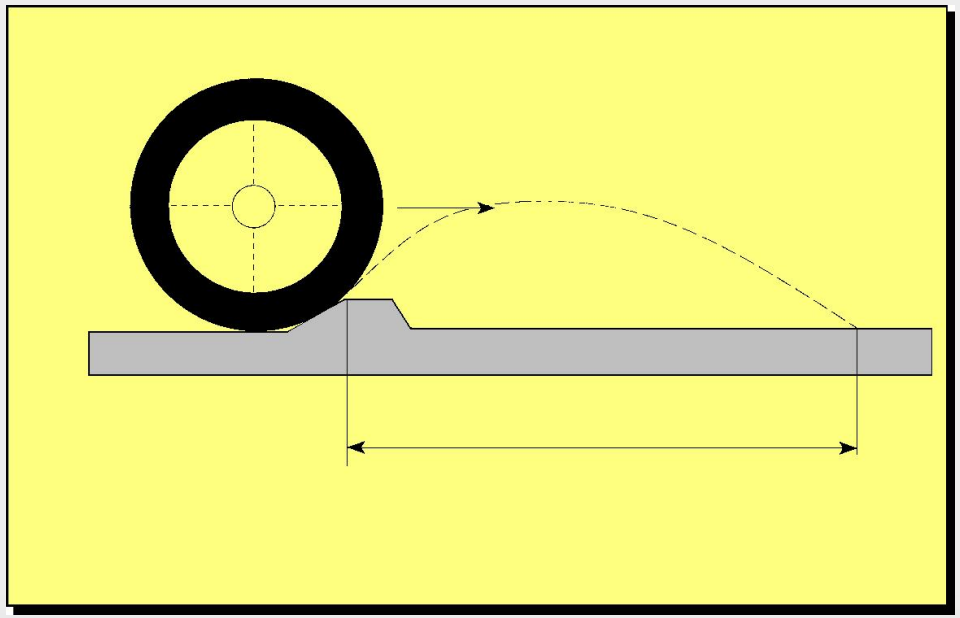
“SPEED DEPENDANT”

for a given shock absorber -

"the higher the linear speed of the shock absorber,

the higher the damping force produced."

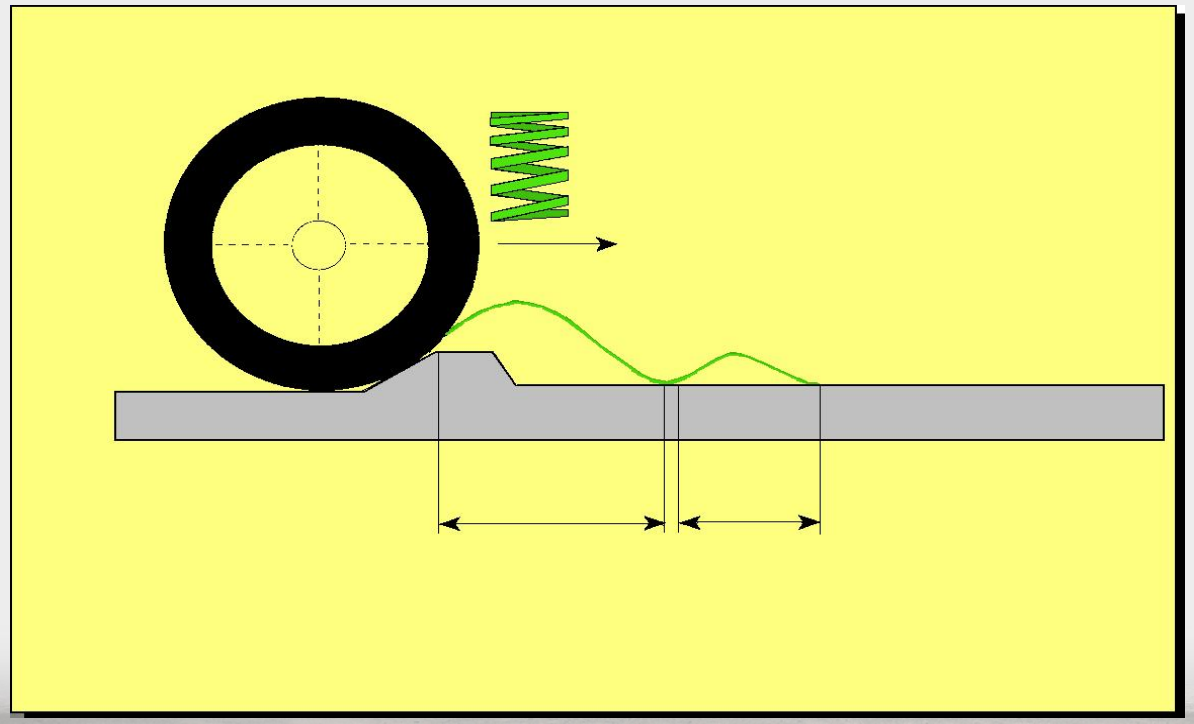
Performance of shock absorbers



Wheel movement without spring and shock-absorber

(no suspension)

Performance of shock absorbers



Wheel movement *WITH* spring and *WITHOUT* shock absorber

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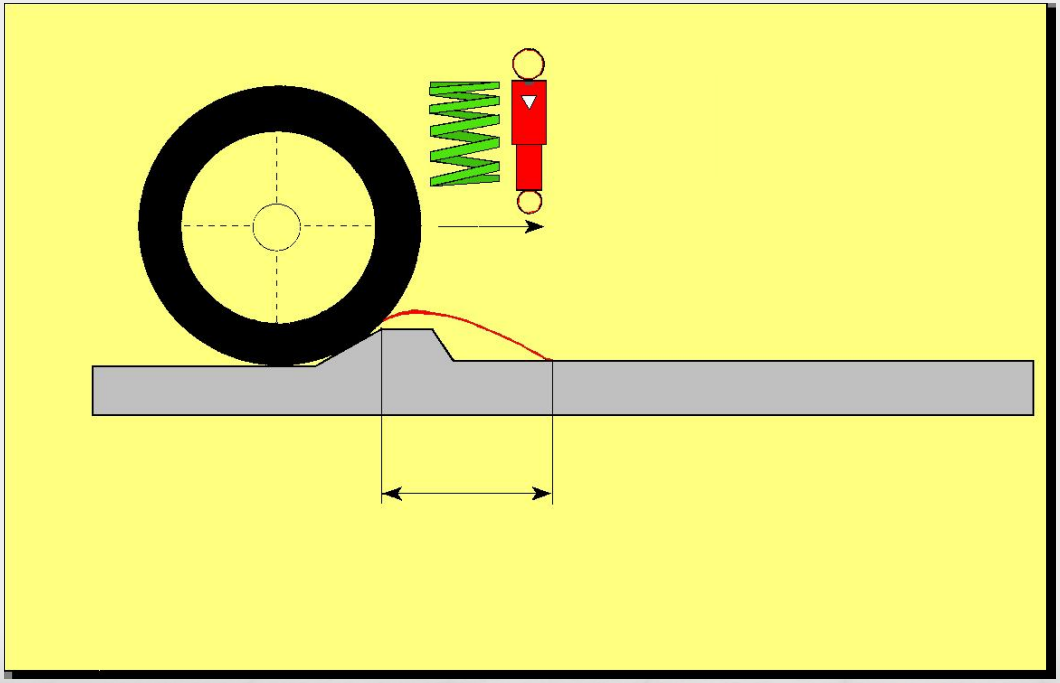
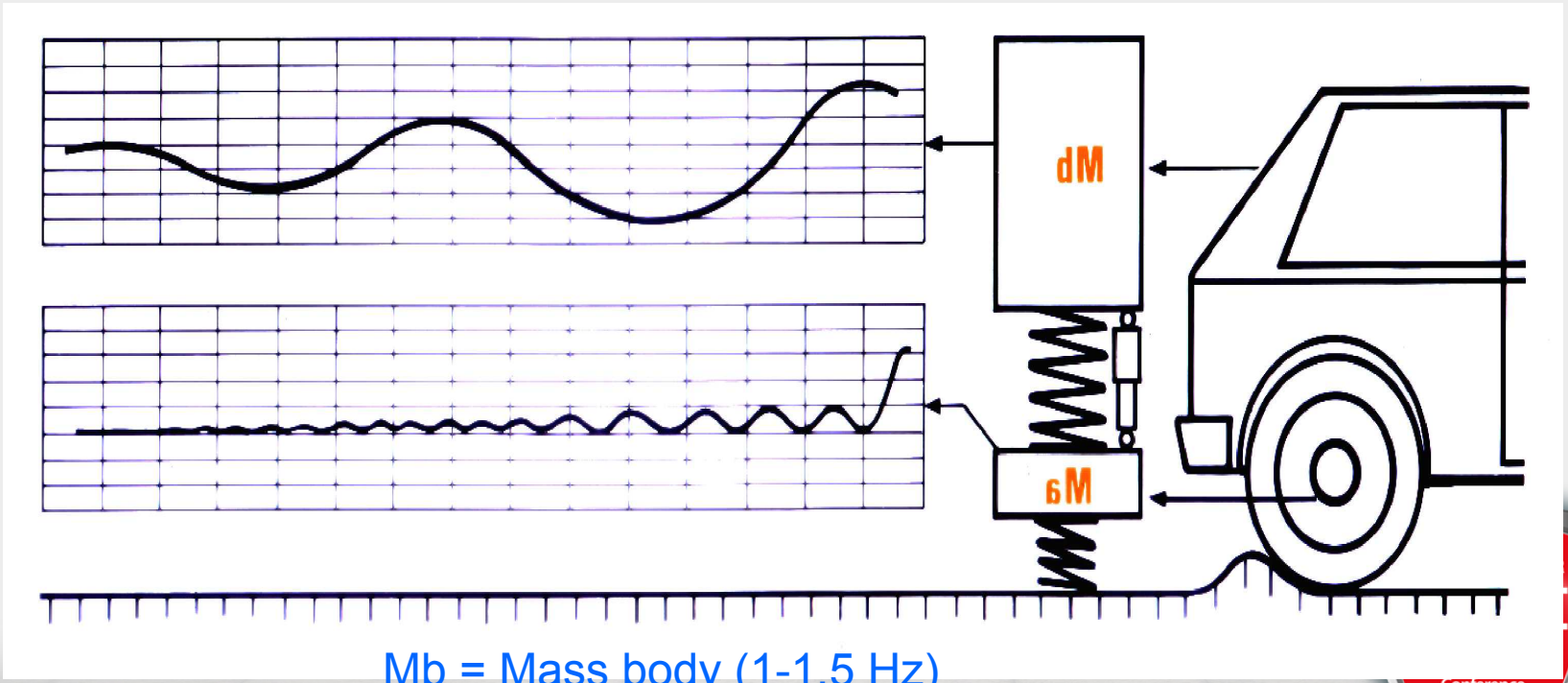
Performance of shock absorbers



Wheel movement *WITH* spring and shock absorber

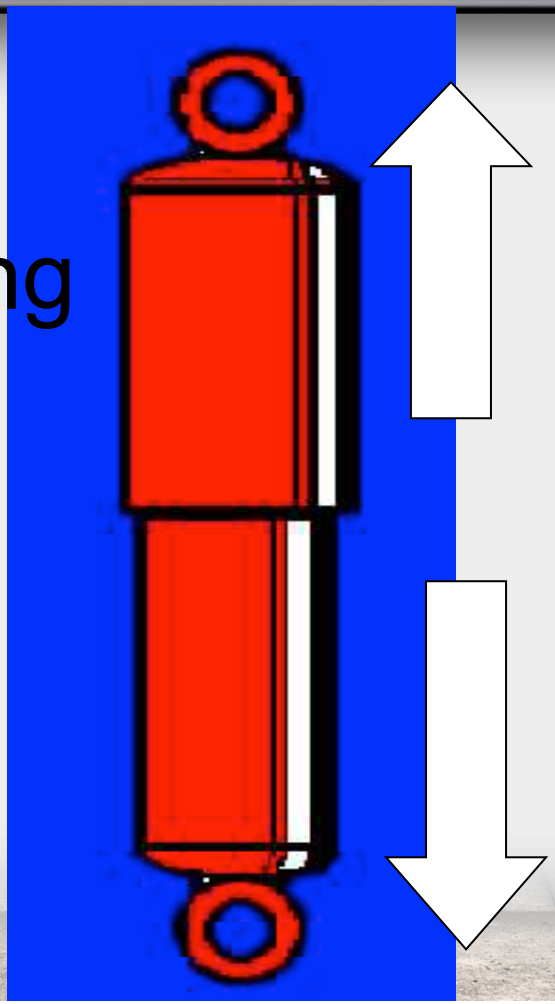
Function of shock absorbers



Mb = Mass body (1-1,5 Hz)

Ma = Mass axle (10-15 Hz)

Double - acting



Rebound

Compression

2 Functions

- *1 Rebound controls the vehicle weight*
- *2 Compression controls the un-sprung weight; (i.e Wheels axles etc.)*
- *& keeps the wheels on the road*

Performance link of tyres and shock absorbers

Tyres provide GRIP

Shocks provide Contact with the road

Without Contact there is No Grip

Tyres only perform with good Shocks

Safety & Performance

=> Good Tyres AND Shocks

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CANTED OVER v's UPRIGHT SHOCKS

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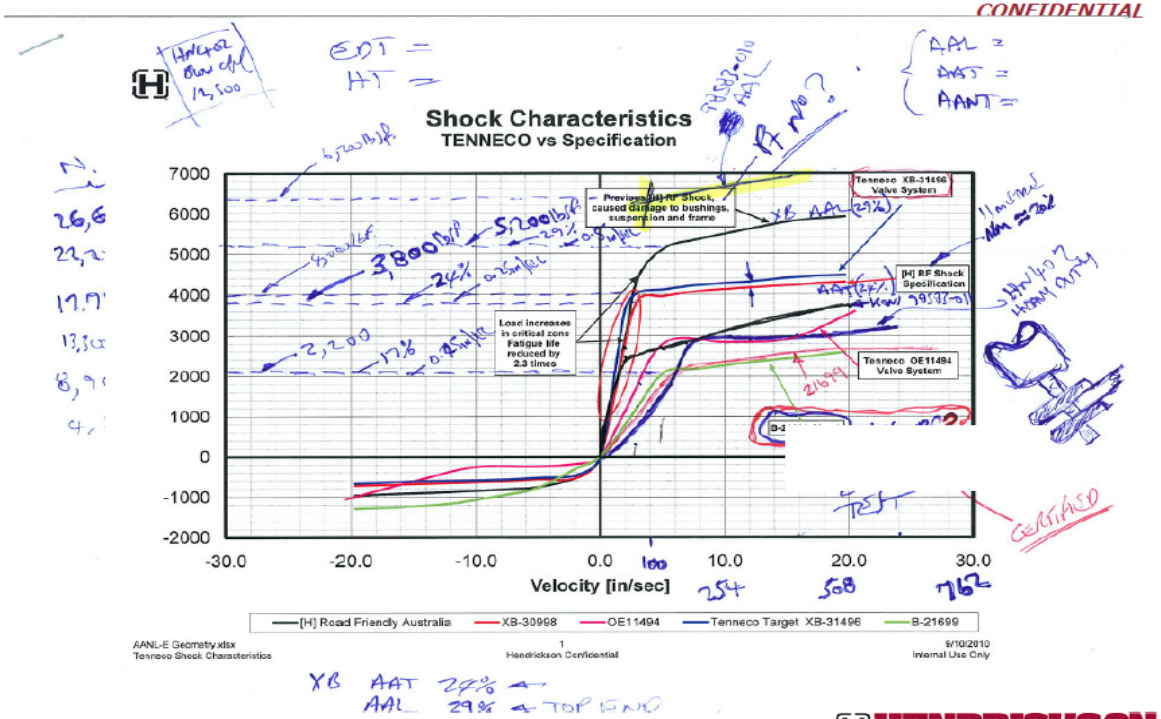
Damping... Not Dampening



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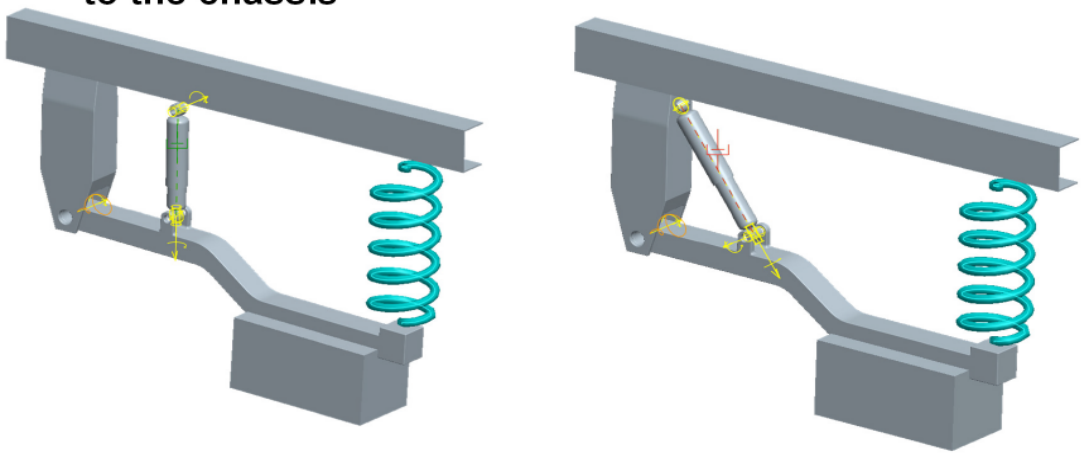
Shock Absorber Positioning

- **The two example suspension arms shown below share the same beam and chassis geometry.**
  - **The left model has a vertically mounted shock absorber, whilst the right has it's shock absorber mounted on an angle to the chassis**



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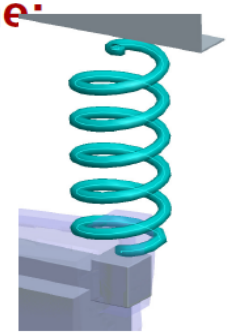
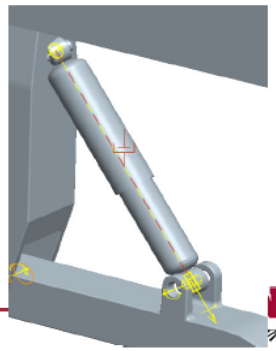
Shock Absorber Modelling

- In both models, the spring rate and shock damping rates are set to be the same:
  - Spring Rate = 500 N/mm



  - Shock Rate = 80 N sec / mm



Shock Absorber Modelling

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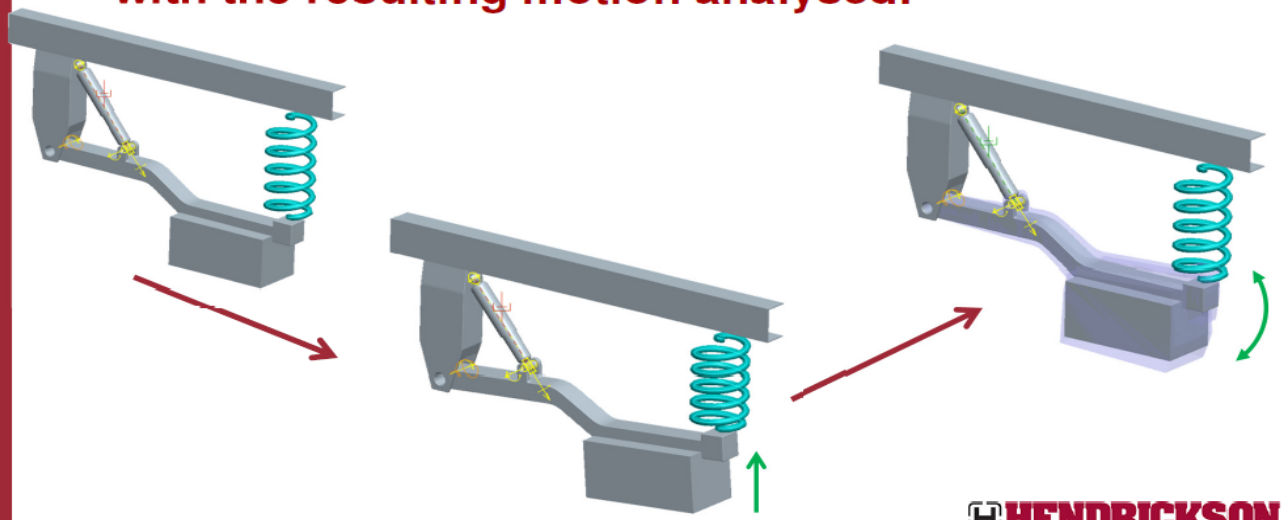
- To analyse the difference between the two setups, a standard road friendly test was simulated – where the suspension is compressed and suddenly released with the resulting motion analysed.



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Suspension Response

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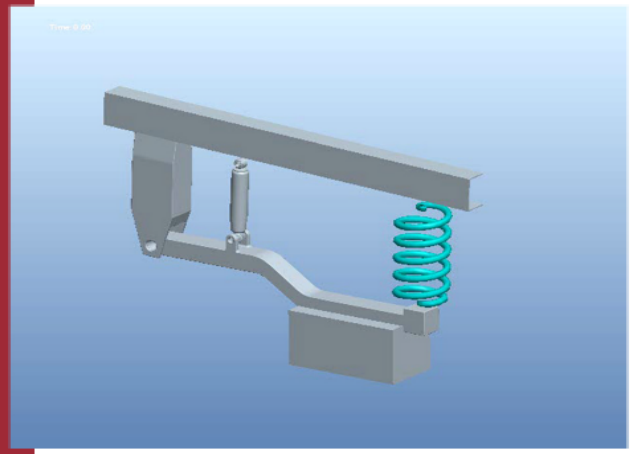
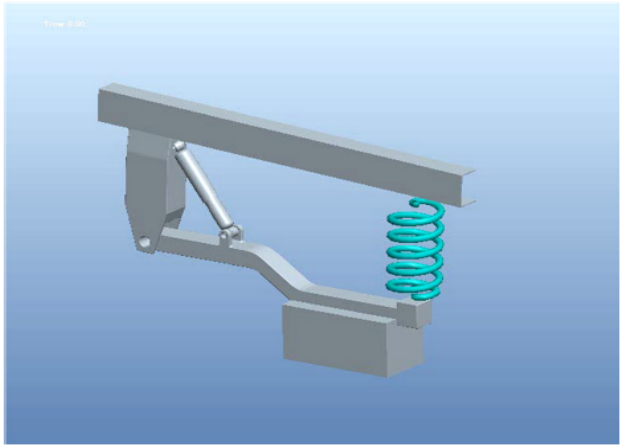
- During simulation, the trailing arm rotation and shock absorber reaction force was measured with respect to time.





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Suspension Response

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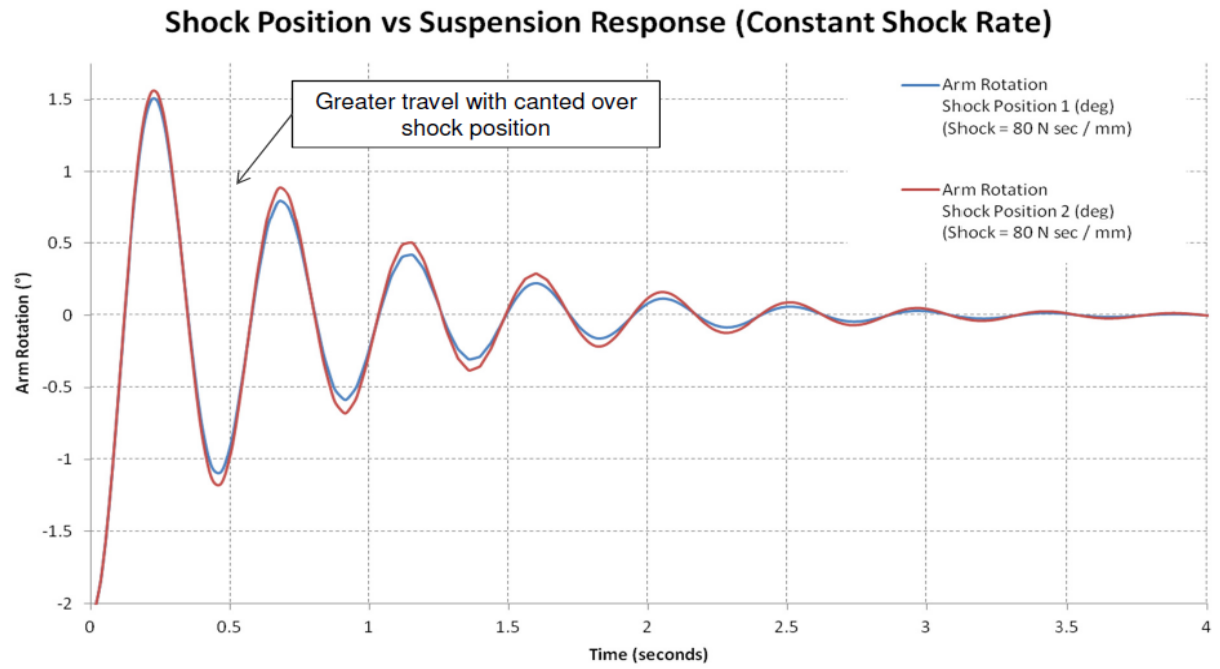

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Suspension Response

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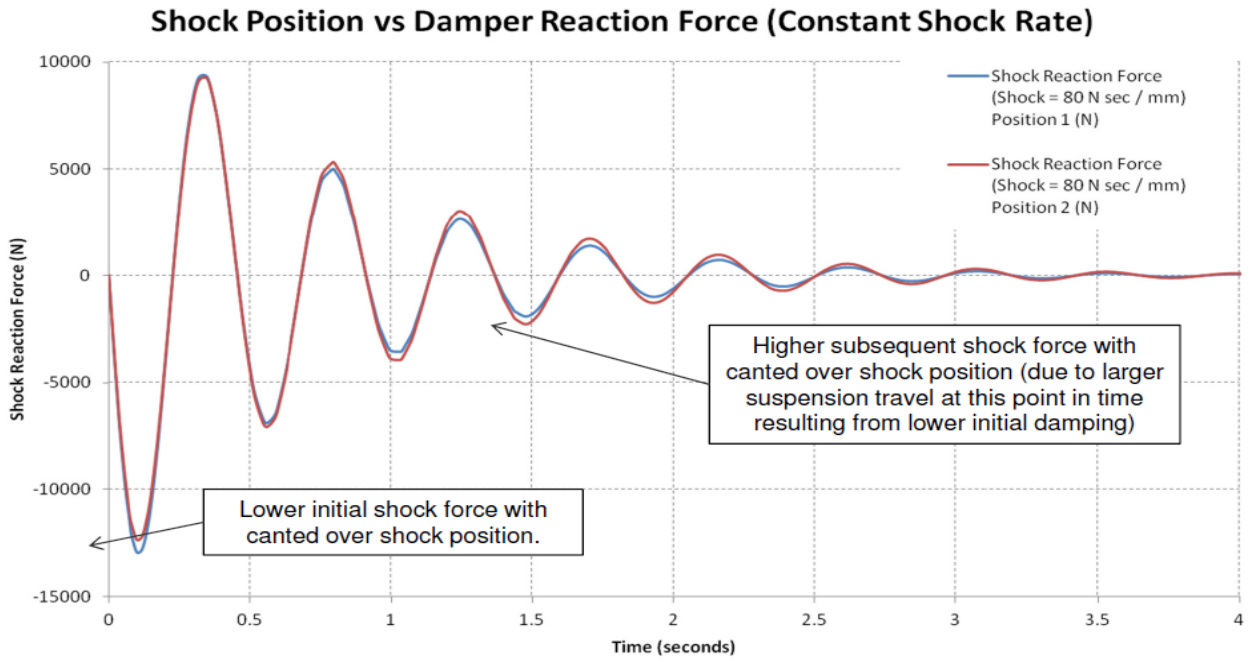

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Suspension Response

- The Damping rates for each configuration can be calculated based on the response, where:

$$D = \frac{1}{2\pi} \ln \frac{A_1}{A_2}$$

Vertical Shock model:

- A1 = 1.507 °
- A2 = 0.801 °
  - D = 10.05%

Angled Shock Model:

- A1 = 1.561 °
- A2 = 0.894 °
  - D = 8.87%

The Angled shock model therefore provides less damping effect to the suspension

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Suspension Response

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- To bring the damping rate back to its original rate, we need to hence increase the shock absorber damping rate if we wish to keep the new shock position without affecting the suspension damping rate.

- Increasing the shock absorbers rate from 80 to 90 N sec / mm and re-running the simulation yields:

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Suspension Response

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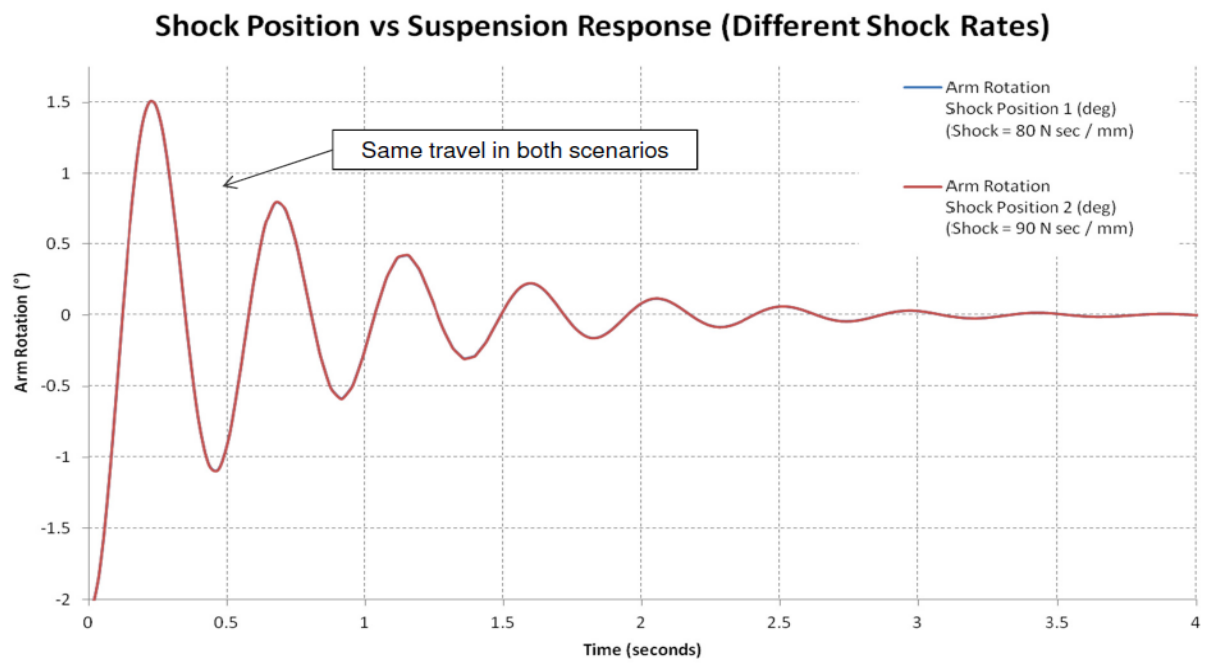

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Suspension Response

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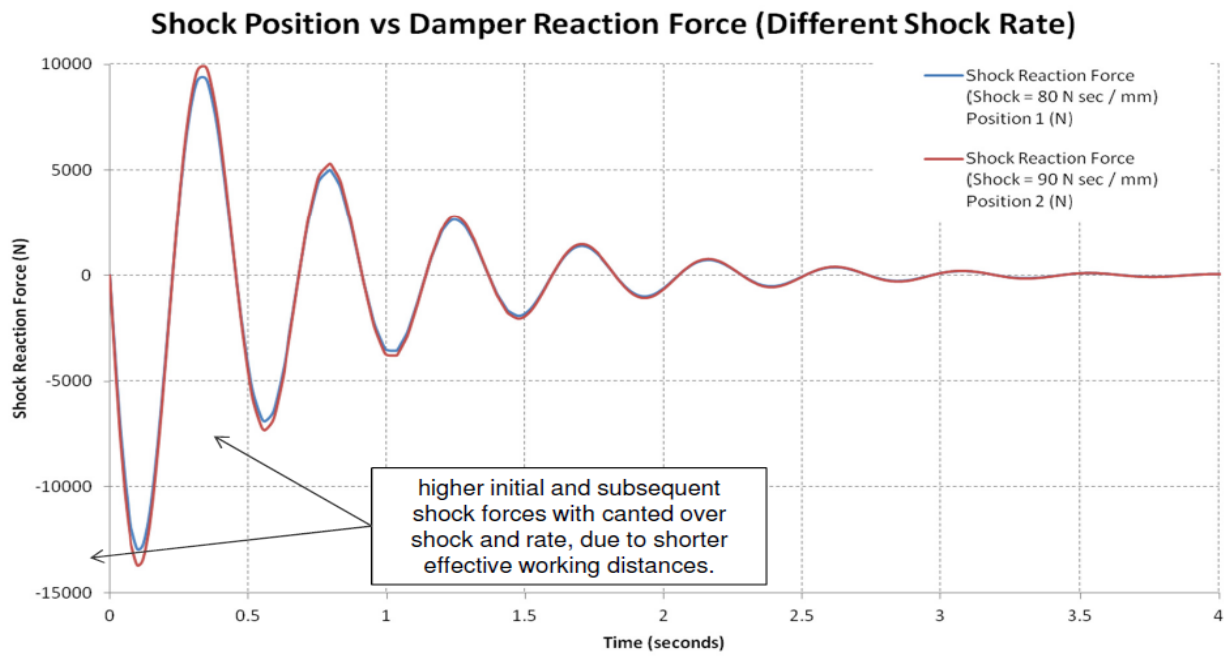

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Suspension Response

- Again, the Damping rates for each configuration can be calculated based on the response.

Vertical Shock model (80 N sec/mm rate):

- A1 = 1.507 °
- A2 = 0.801 °
  - D = 10.05%

Angled Shock Model (90 N sec/mm rate):

- A1 = 1.506 °
- A2 = 0.804 °
  - D = 9.99%

- Hence damping rates between the two models are now the same.

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Conclusions

- Changing the Shock Absorbers orientation to the suspension beam will affect the suspension damping rate due to a change in the damper travel and lever arm distance
- The Shock Absorber damping rates can be tuned (through valving) to achieve the same suspension performance as the vertically oriented shock
- Shock absorber reaction forces will change when compared to the original orientation and rates
- Shock absorber rates have little effect on the suspensions natural frequency (this is driven predominantly by the air spring and sprung mass)

Damping Level and Road Friendly

- With good damping concessions have been given to allow those vehicles to equipped with Road Friendly suspension to carry more mass

- Provided certain conditions are met

Road Friendly Suspensions

Vehicles with a road friendly suspension systems do less damage to the road infrastructure for the same suspension load on a similar vehicle with a non road friendly suspension.

Regulators could therefore either reduce the road taxes or allow increased suspension loads on vehicles with road friendly suspensions.

This happens in Europe and to some extent in Australia.

Road Friendly Suspensions

In the late 1990's Australia was prepared to go down the European path and define all airbag suspensions as being road friendly.
However some additional limits where placed on the definition.

Australian road friendly system was defined : the suspension must be road friendly and for the axles to be fitted with dual tyres.

If these criteria are met then additional mass may be granted.

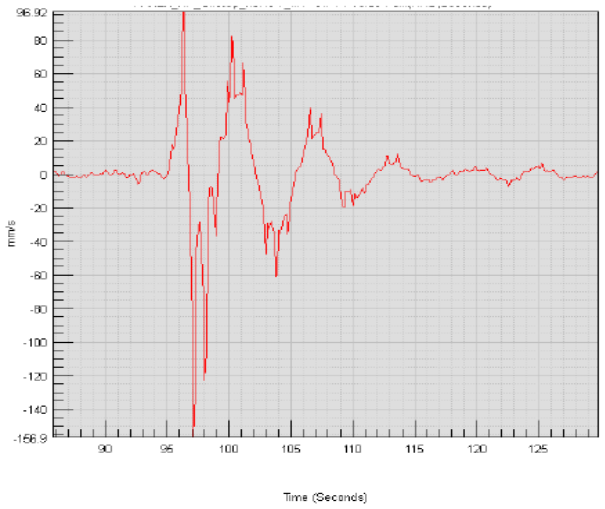
Road Friendly Suspensions

Drop tests performed by BPW Transpec


TURNING VEHICLE
RENTCO
TRANSPORT EQUIPMENT
RENTALS

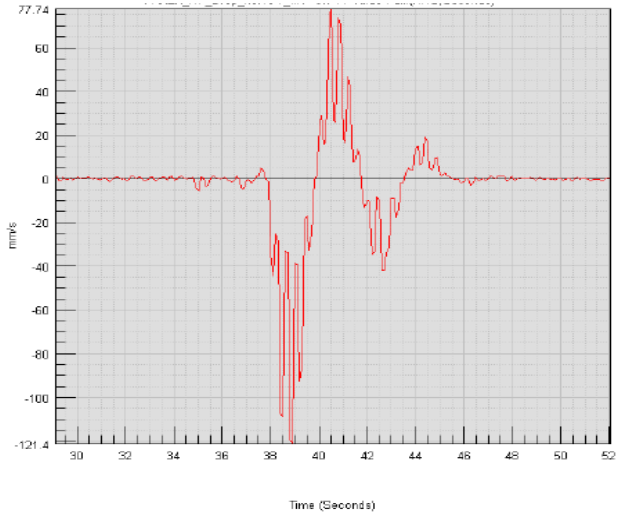
Comparison of Velocity

80mm Drive Off-Step



- Average peak velocity
  - Compressive = 132.5 mm/s
  - Rebound = 89.3 mm/s

80mm Chassis Drop



- Average peak velocity
  - Compressive = 118.6 mm/s
  - Rebound = 73.5 mm/s

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Comparison of RF Test Methods

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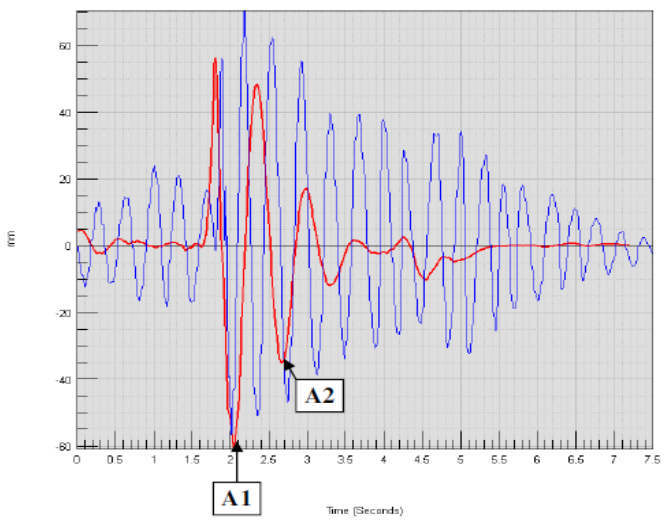
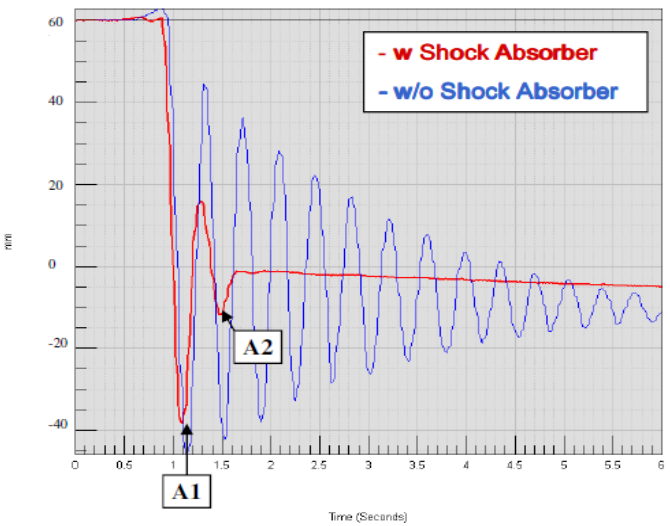
80mm Drive Off-Step



$$DM\,\% = \frac{1}{2\pi}\ln\left(\frac{A_1}{A_2}\right) = 9.34\%$$

80mm Chassis Drop



$$DM\,\% = \frac{1}{2\pi}\ln\left(\frac{A_1}{A_2}\right) = 18.96\%$$

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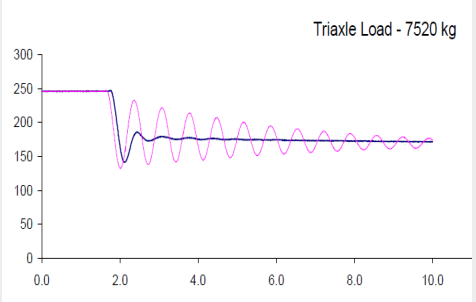
Details below for the trace



Conclusion

The suspension as tested meets the criteria to be registered as a complying road friendly suspension under the certification requirements of VSB 11, issued April 1999 by FORS.

Criteria for Compliance as a Road Friendly Suspension

In accordance with VSB 11 a conforming road friendly suspension must fall within the following limits:

1. Frequency of sprung mass in a free transient vertical oscillation must not be higher than **2.0** Hz.
2. Mean Damping Ratio (DM) must be **> than 20% of Critical Damping** (Co) for normal operation.
3. Damping Ratio (DR) must be **not more than 50% of DM** with dampers removed.

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Basic design styles of Shockers used for Trucks and Semi Trailers

The same general design is used for Truck and Trailer shock absorbers.

Twin Tube design uses oil and valving to control the rate of damping.

Compression stroke has low resistance.

Rebound stroke has high resistance.

Twin Tube Shock Absorber

Dampens oscillations between axle and chassis.

Improves safety, driving comfort, and helps road life.

Different hysteresis in bump (compression) and rebound (extension).

Damping forces are also velocity dependent.

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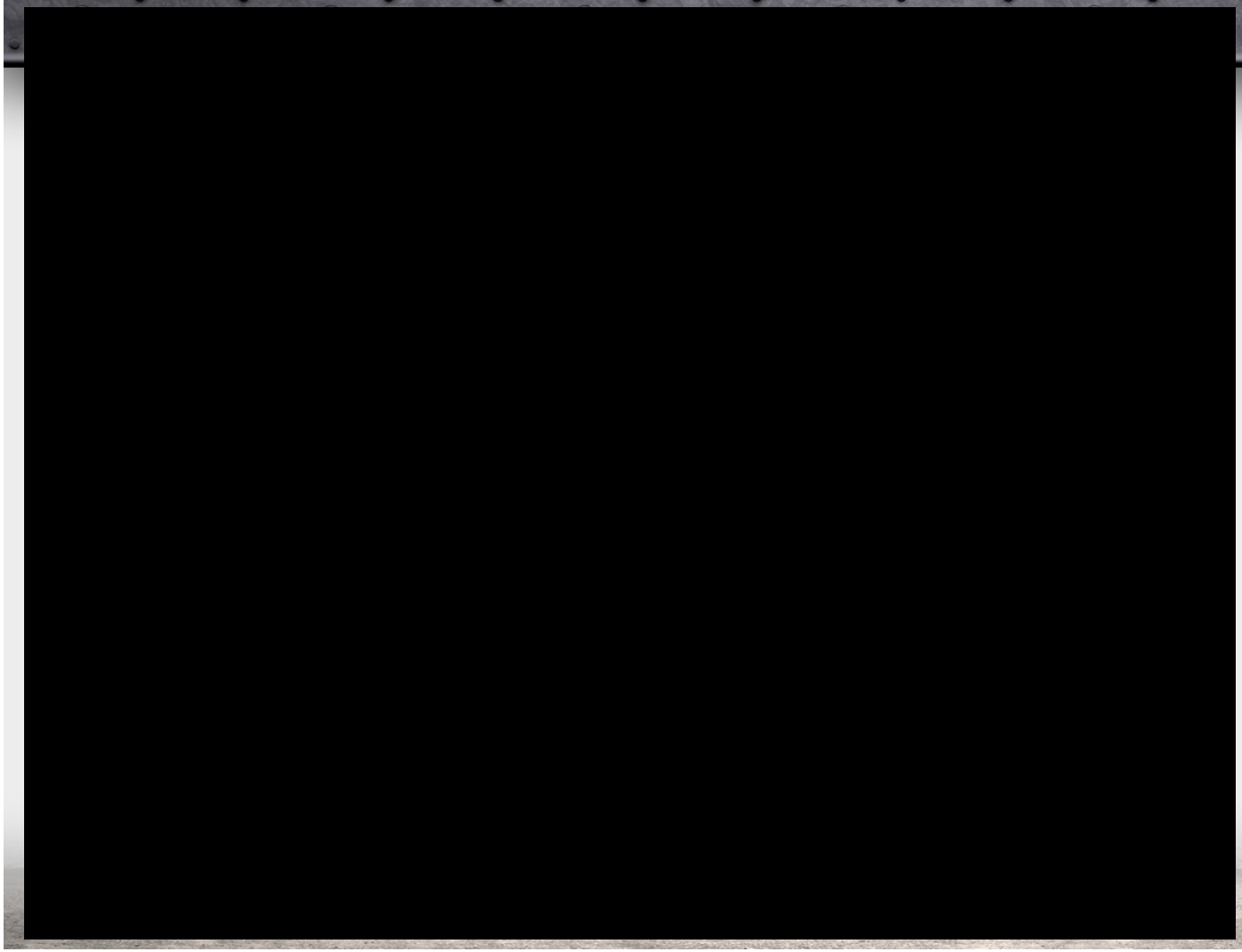

http://www.youtube.com/watch?v=vcSH2z706rU

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Suspension Geometry

Shock absorbers are designed for certain particular conditions.

Front axle/ Drive axle / Trailer axle

Installation location;
Front mount / top mount/ inclined and rear mount.

All can have different damping rates

Shock absorbers are designed to operate in a given position suspension geometry.

Road Friendly ?

Multi Leaf-spring suspensions need soft to moderate damping rates.

Road Friendly ?

Taper leaf-spring suspensions need moderate to firm damping rates.

Multi Leaf-spring suspensions need soft to moderate damping rates.

Road Friendly ?

Air sprung suspensions need firm to extremely stiff damping rates.

Road friendly even stiffer !!

Taper leaf-spring suspensions need moderate to firm damping rates.

Multi Leaf-spring suspensions need soft to moderate damping rates.

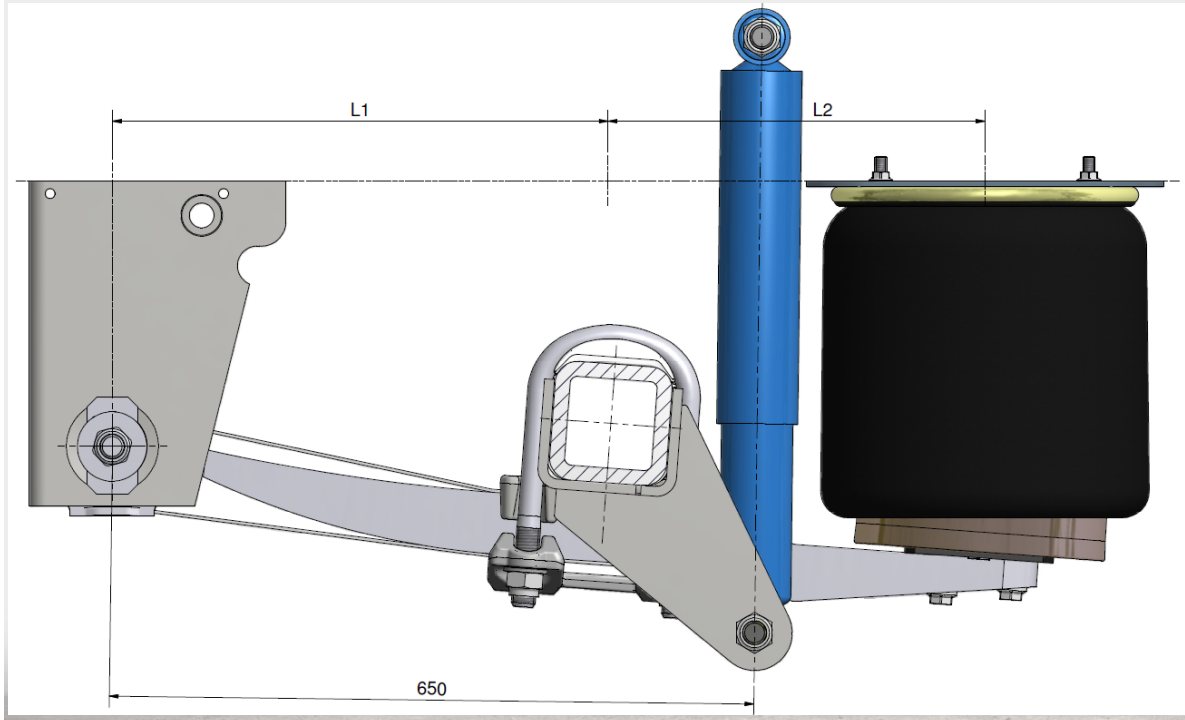
Not Interchangeable

The next 5 slides represent different shocker attachment locations.

Each shocker will have a different hydraulic characteristic and should not be swapped around, even if the lengths and fittings are the same.

Suspension Geometry

BPW rear mount shock absorber position.



SHOCKER LENGTH

SUSPENSION FULL UP - 509mm
SUSPENSION AT R/H - 601mm
SUSPENSION FULL DOWN - 734mm
TOTAL SHOCKER STROKE - 225mm

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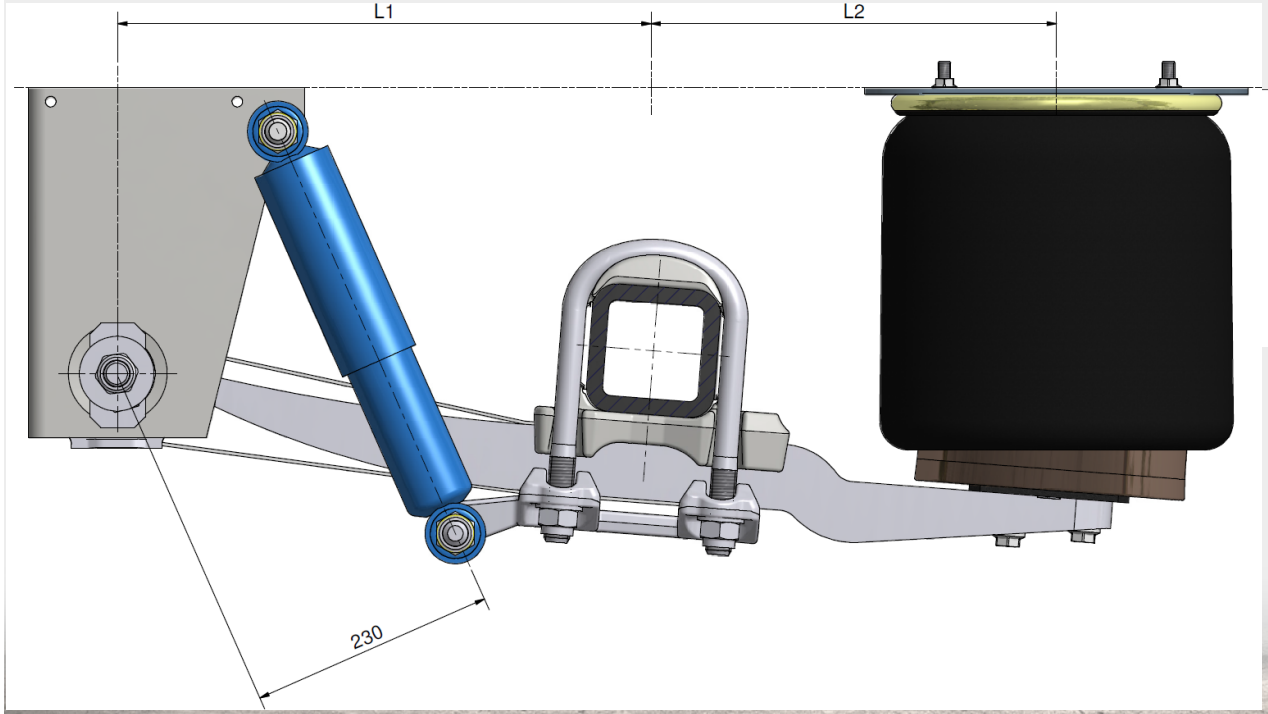
Suspension Geometry

BPW front mount shock absorber position.



SHOCKER LENGTH

SUSPENSION FULL UP - 379mm
SUSPENSION AT R/H - 412mm
SUSPENSION FULL DOWN - 464mm
TOTAL SHOCKER STROKE - 85mm

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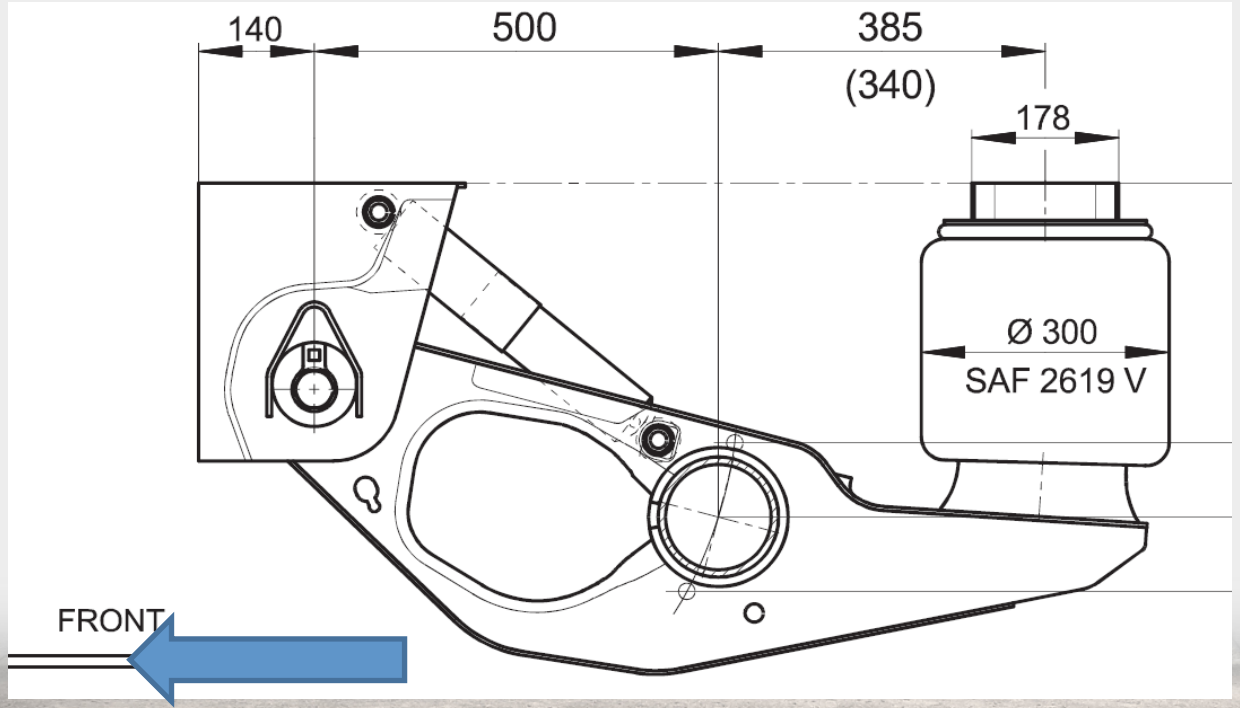
Suspension Geometry

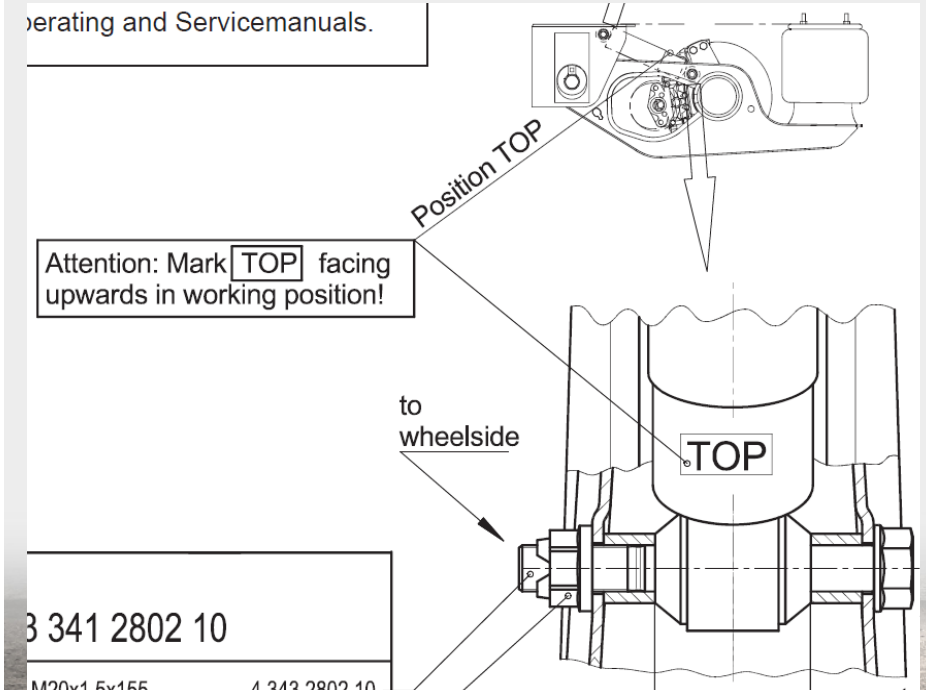
SAF showing their shock absorber.

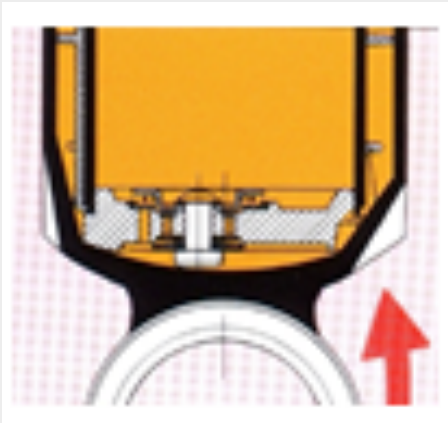


Short stoke shocker.

Suspension Geometry

SAF shocker has special foot valve.
So the shocker is marked to indicate top.





Eccentric Bottom Valve- designed to suit the angle of installation

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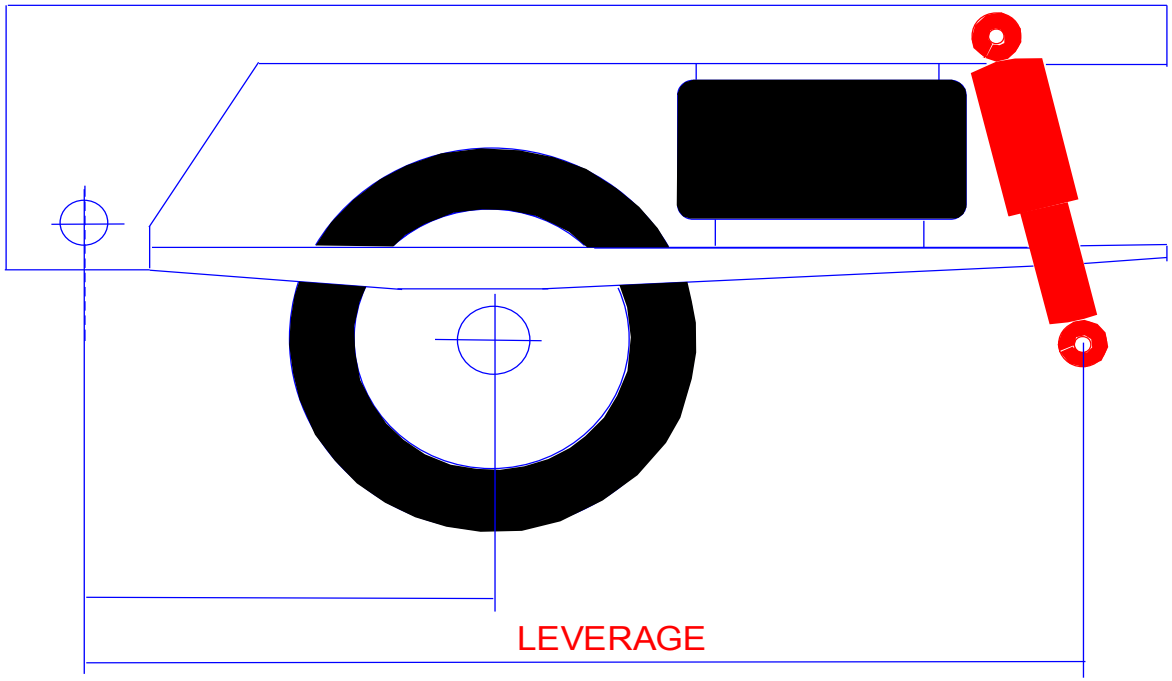
Suspension Geometry

Rear mount = long stroke & moderate damping rate.



Suspension Geometry

Hendrickson example Drive or Steer.

Testing - How is it done ?

Koni tests with a special shocker dynamometer

In practical terms field check -

Working the shock absorber in and out by hand

(providing it is held vertically)

will provide only a small picture of damper performance.

(but, is not an adequate test of full damper performance).

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Maintenance !!!

Regular Inspections

- Mounting bushes
  - ❖Note, any suspension bushes must always be tensioned at “static” ride height.

Shock Absorber Bush Damage

New shocker –
top bush

Old shocker –
top bush

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Shock Absorber

From some bench testing and field trials with assistance from a trailer builder we were able to set up some fault conditions of actual performance testing and we could come to the following conclusions:

A lack of maintenance (insufficient control of the tightening torques of the shock absorber bolts) can cause a wear to the shock absorber steel sleeve bush which can result into a dramatic reduction of shock absorber life.

The investigation of the returned parts revealed a reduction of life from 100 % to 20 %

Summary:
We see clear evidence to show a lack of maintenance will lead to premature failure of shock absorbers.

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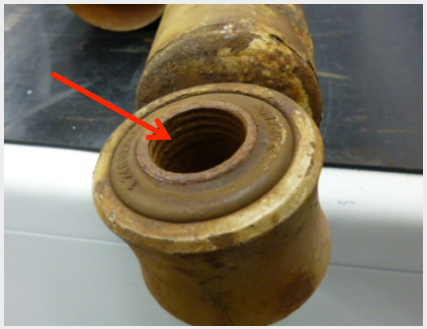
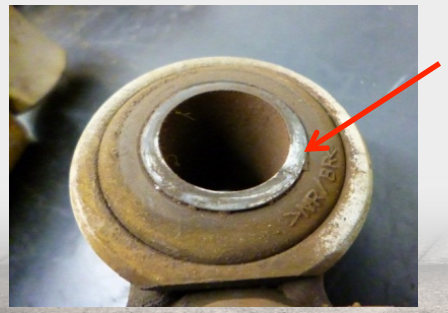
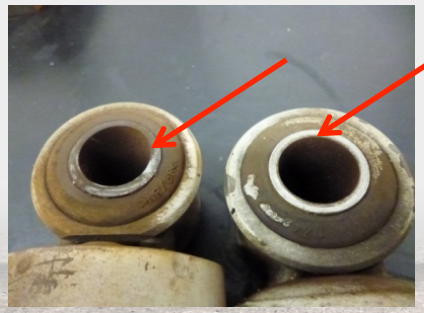
Shock Absorber

Indications of damage from loose shocker mounts:







- Clear indications of loose shocker bolts shows signs of wear.

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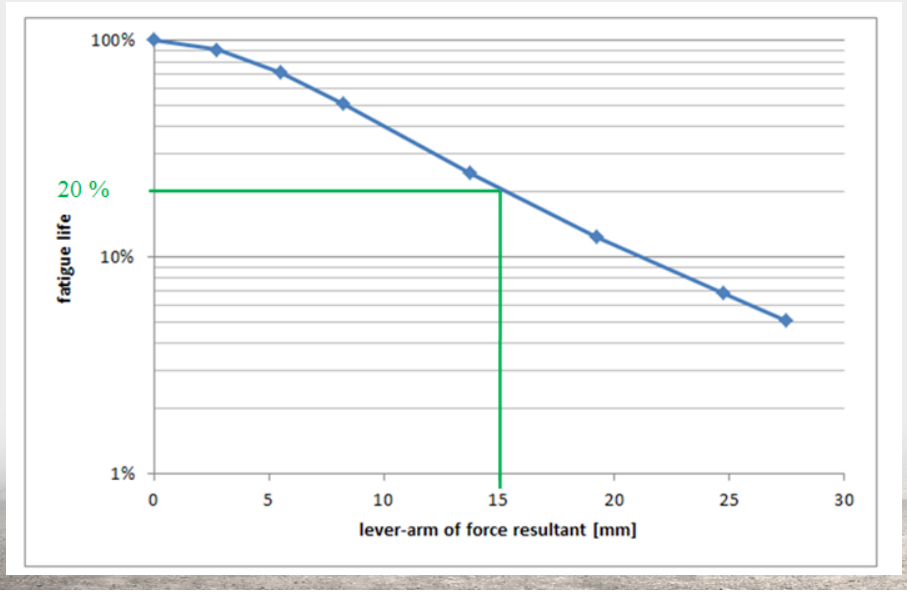
Shock Absorber

Effect on the fatigue strength by loosening the securing bolt/nuts

Impact of the worn shock absorber steel sleeve bushes (caused by lack of maintenance - loose bolts) on the fatigue life of shock absorber.



Maintenance !!!

Regular Inspections

- Oil leak

  (as opposed to “Misting”)

Maintenance !!!

What is "Misting"

- *Dampers with very high forces can generate high temperatures.*
- *This then leads to some vaporization.*
- *The linear action of dampers will draw some oil past the seal, which condenses on the outside.*

Shocks drips = not OK

Shock sweats = OK

Maintenance !!!

Tyre wear

- Check tyre tread for regular worn patches which may indicate poor damping

Maintenance !!!

Observation

- Have someone observe the behaviour of the wheel as the vehicle moves along the road.

Does it move too freely?

Maintenance !!!

Damper temperature

- Check the temperature during or immediately after a trip for any variations within the axle groups.

  (left side usually works harder).

(This is just a small indication & not definite enough within itself)

Maintenance !!!

Damper testing

- Remove the dampers at regular intervals (eg.@ 150 000 – 200 000 km) for testing.

  A rotation of a spare pair through the fleet, could be used.

Maintenance !!!

Statistics

- Keep accurate records of all aspects of suspension maintenance.
- Over time, a statistical picture will emerge.

Shock Absorber Assessment (Page 1)

The following notes are intended to help make an assessment of the shock absorbers function:

1) A thin film of oil on the outside tube of the shock absorber is not necessarily an indication of reduced damping efficiency of the shocker. With new shock absorbers, there is occasionally residual oil in the area under the protective tube that originates during assembly, but this is not a cause for concern. The oil film required on the cylinder pushrod could evaporate and condense on the colder outside tube (the shock absorber sweats).

2) The outside tube of the shock absorber has a film of oil and looks damp.
More than 80% of the outside tube surface is covered with clearly visible traces of oil. Disconnect the bottom mount and push /pull by hand. There should be no free play when doing the push – pull test
If only a small amount of force is needed to move the shocker – replace the shock

3) The shock absorber eyes/bushes are clearly deformed, i.e., oval – replaced the shock.

4) The rubber bushes of the shocker are badly worn and deformed then the shocker bushes must be replaced

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Shock Absorber Assessment (Page 2)

5) The steel tubes in the shocker bushes are deformed, worn or split – replaced the shock.

6) Any mechanical damage inside the shock absorber can be determined by a manual check.

7) No mechanical noises (rattling or similar of loose bits) should be heard.

8) If a shocker problem is suspected check shocker temperature with a heat gun immediately after standstill.

A reliable assessment of a shock absorber operational condition can only be achieved by a full system performance test on an appropriate testing device.

Refer to ARTSA website under codes of practice Air Suspension

http://www.artsa.com.au/RFSWorkbookReadOnly.pdf

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Shock Absorber Temperature

To dampen suspension the shock absorbers convert the energy they absorb into heat.

Within a given suspension temperature can be used as a guide to see if the shockers are working equally.

That means measure the temperature directly after a given run and all the shocks should be the around the same temperature.

If all shocks are warm and all have very similar temperatures then they are most likely ok.

Large variations in temperatures within a suspension group would indicate shocks with low temps are no good.

Advisory temperatures of the lower tube 70-80°C can be measured. Sometimes temperatures over 100°C have been known.

Temperatures should be within 20% of each other.

There is no specific temp for good or bad shock absorbers it depends on many things.

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Shock Absorber PDC

The large-volume series production shock absorbers are optimally matched to the suspension on the vehicle.

With the majority of truck and trailer suspensions the damping rate of the shockers offered/supplied has to cater for a very wide load range.

For special applications, there is a load-dependent (PDC) - damper

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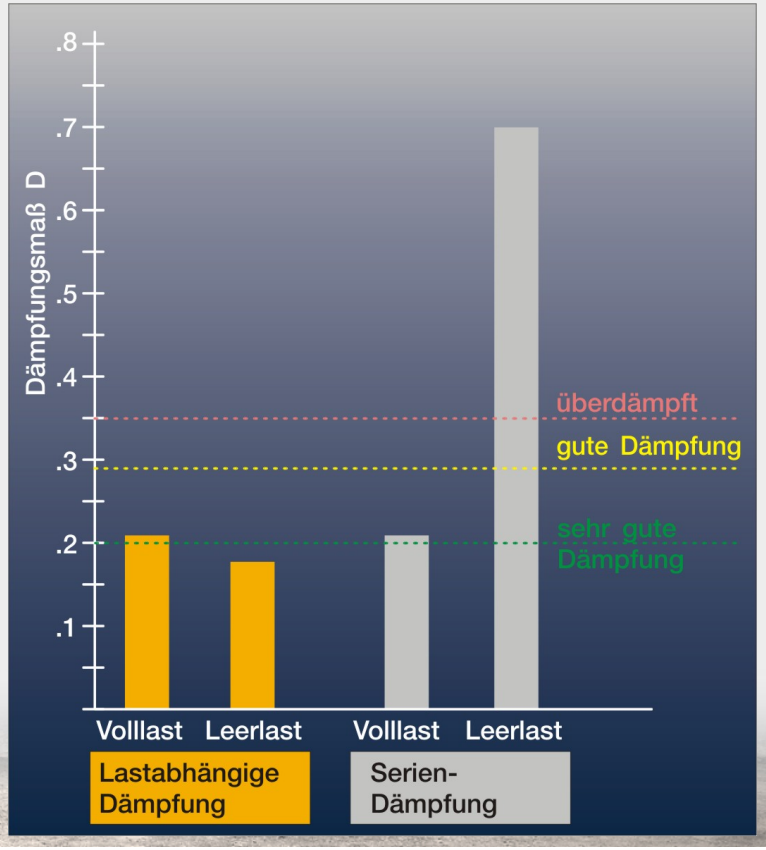
PDC Weight Dependent Shock Absorber

Via the air bag pressure damping is adjusting continuously the loading condition of the vehicle

More comfortable ride under all loading conditions

Weight dependent damper Yellow

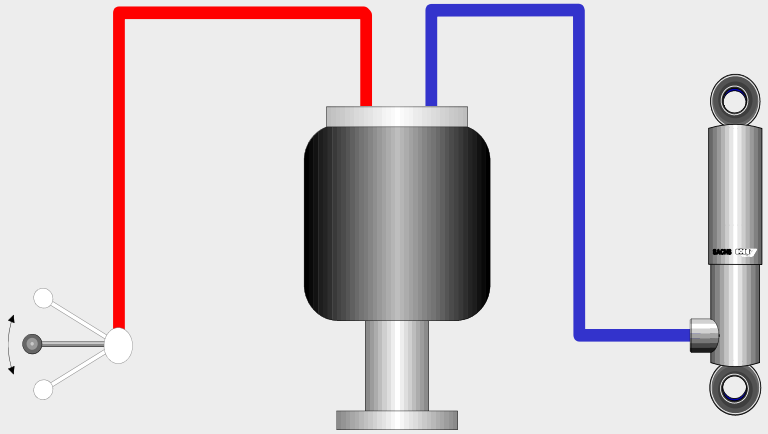
Standard fixed damping shock absorber Silver



How the PDC Shock Absorber Functions

PDC = Pneumatic Damping Control

Air bag pressure depends on the load

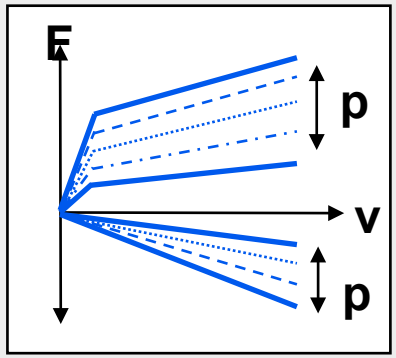


Air suspension valve

Air bag

PDC shock absorber

Damping force depends on the load



Automatic level control

Automatic adaptation of bag pressure

Automatic adaptation of damping characteristics

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Questions


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Shock Absorbers

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Ian Thomson - BPW Transpec

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