

Vehicle and Driver Vibration



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Seminar on *Low Impact Vehicles and Tyre Pressure Control*
Perth Racecourse, 23 June 2010

Outline

Ride characteristics in timber logging trucks.

Health and safety aspects on whole-body vibration (WBV).

EU & UK limits on vibration exposure at work.

Performance of heavy truck suspension systems.

TPC system found to reduce average ride vibration by 8 %.

What TPCS can and can't do to vibration:

- Long wave bouncing can't be isolated.
- Road megatexture (potholes, corrugations) isolated by much more than the 8 %!

Roadex IV will map WBV isolation by TPCS as function of frequency.

Ride characteristics in timber logging trucks

Dominating vibration patterns:

- Vertical bouncing (z-axis).
- Pitch-related fore-aft (pitch => x).
- Roll-related lateral (roll => y).

Frequency content: Mainly 1 - 10 Hz.

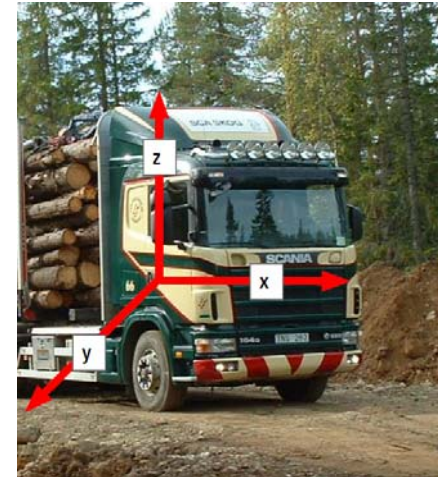


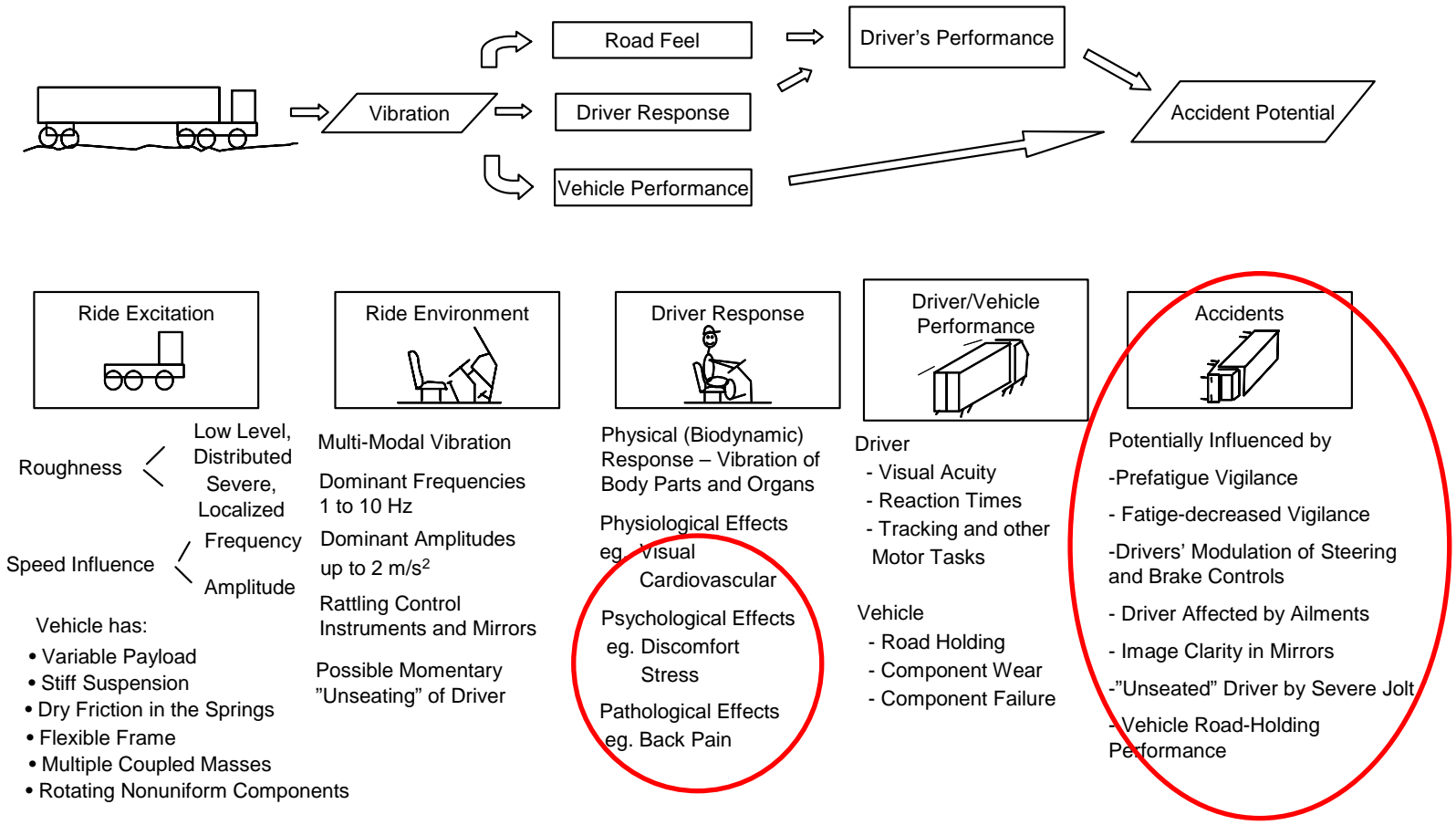
Photo: P Granlund

Amplitude peaks over 2 m/s^2 ; "Extremely uncomfortable".

Intensities typically $0.5 - 1.4 \text{ m/s}^2$, depending on road condition, speed etc.

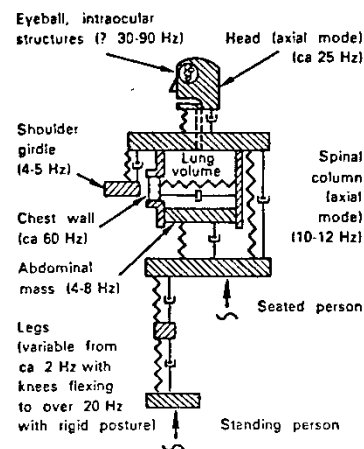
Roadex III result on the Beaver Road 331: $A(8) = 0.76 \text{ m/s}^2$.

Health and safety aspects



[Highway Safety Research Institute, USA, 1982]

Health and safety aspects (2)



[von Gierke et al]

Truck ride in the humans sensitivity range of 0.5 - 80 Hz.

=> Resonance in eye globes, spine and stomach.

Seat vibration intensity often in the ISO 2631-1 "Health caution zone"

NP professional drivers have 3 times more stress related heart disease => Dies at lower age.

Musculoskeletal pain in neck, shoulders and back.

Health and safety aspects (3)



Photo: Niklas Thunborg.

Crash rate strongly correlated to increased road roughness.

Bumps – stressing effect.

Long wave road undulations – create hazardous drowsiness.

Road grip and vehicle stability reduced by dynamic phenomenas, such as weight transfer and bump steer.

Icy roads: Roll-related lateral buffeting may trig skid crashes.



Professional drivers must be under the EU limits.

Control of Vibration at Work Regulations 2005



The UK regulations include the EU limits:

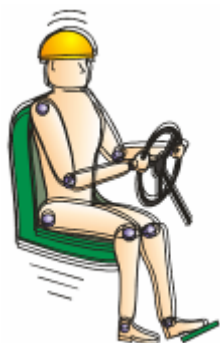
- Action Value of $A(8) = 0.5 \text{ m/s}^2$.
- Exposure Limit of $A(8) = 1.15 \text{ m/s}^2$.

The forestry sector is under a transitional provision until 2014. However:

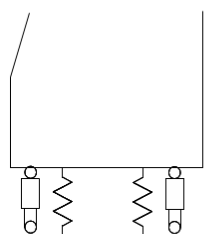
- The provision applies only to the Exposure Limit.
- Exceeding the Action Value 0.5 m/s^2 still calls for action!

Visit www.hse.gov.uk/vibration for more info.

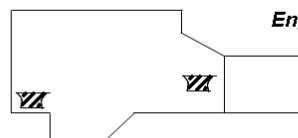
Truck suspension systems



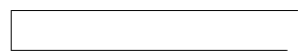
[EU Guide to good practice on WBV]



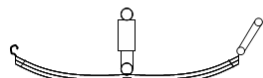
Cab susp.



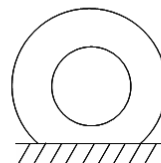
Engine susp.



(Flexible frame)



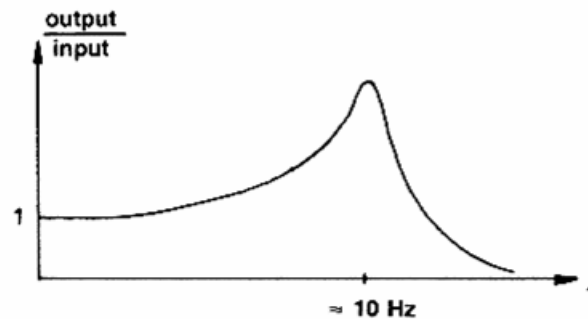
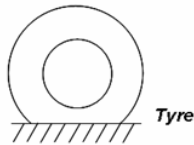
Chassis susp.



Tyre

[H Lindh, Volvo 3P]

The tyre acts as a spring



[H Lindh, Volvo 3P]

- < 10 Hz: Road profile input = Tyre output
- @ 10 Hz: Tyre wall resonance makes output up to 3 x input
- > 10 Hz: Input is isolated down to less than 25 %

In TPCS low pressure mode, both stiffness and eigenfrequency are lower => reduced ride vibration.

The tyre enveloping effect

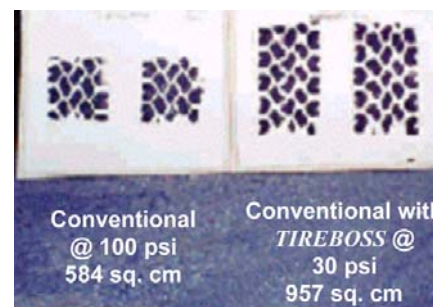
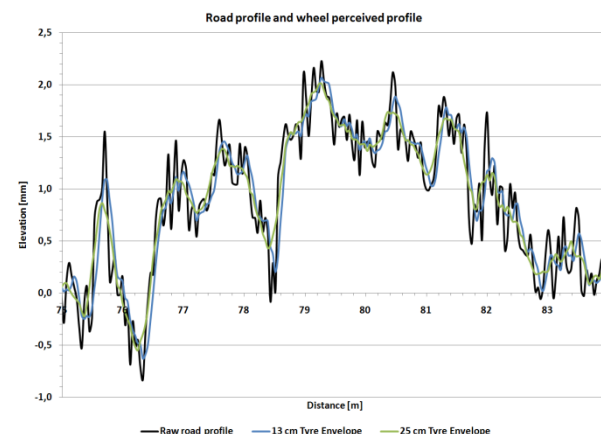
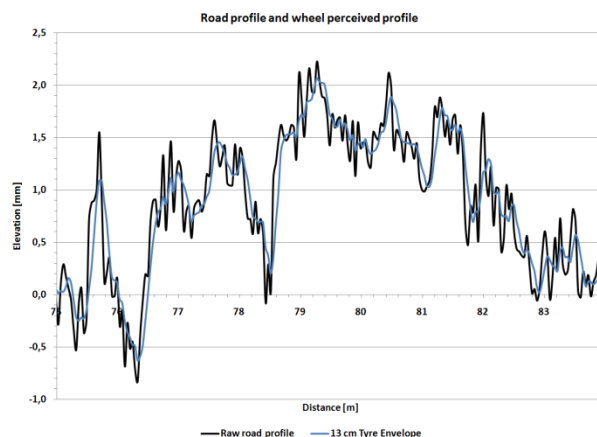
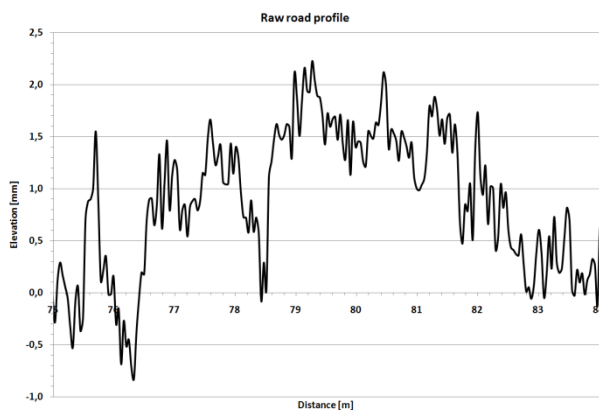


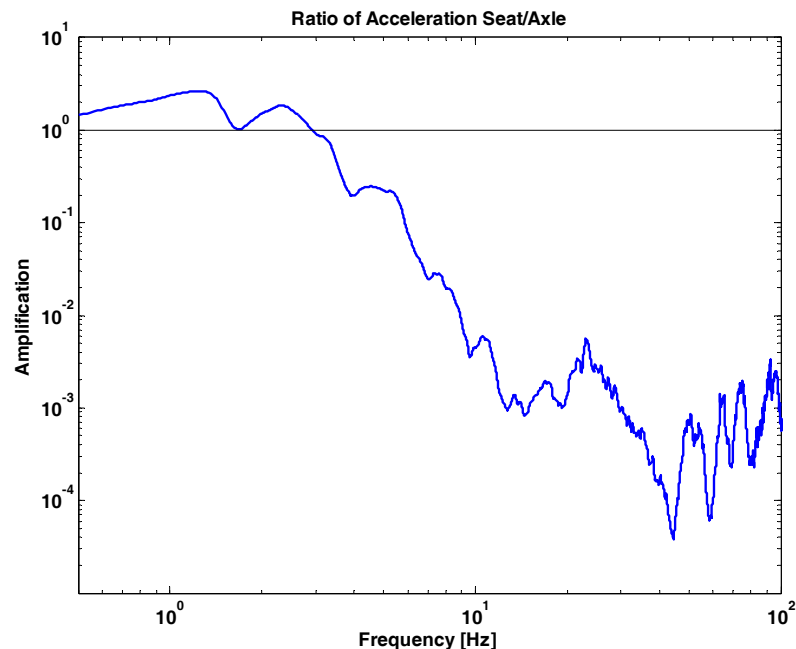
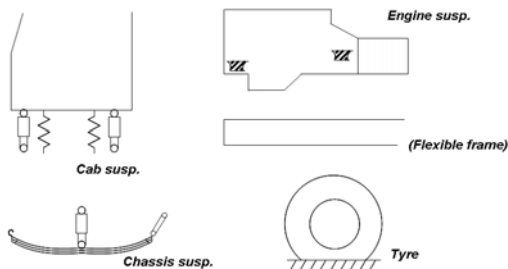
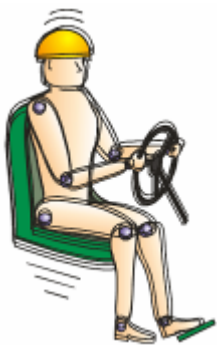
Photo: A Bradley



Raw road profile 13 cm Tyre Footprint 25 cm Tyre Footprint

In TPCS low pressure mode, the increased footprint length improves the tyre's smearing effect on the road profile.
=> Reduced ride vibration.

Net performance of the suspension systems



Roadex III findings:
 (Note: Graph is in log/log-scale)
 > 10 Hz: Up to 99.9 % isolation
 < 3 Hz: Amplification.

TPCS reduced average vibration by 8 %

RESULTAT

FRÅN SKOGFORSK NR. 22 2004



SKOGFORSK

Lugnare körning och mindre vibrationer med CTI på virkesfordon

Per Granlund

Bilden visar: Det förklarar som används i studien, en Scania av år 2003 utrustad med CTI.

Skakningar och vibrationer kan vara ett stort arbetsmiljöproblem för föraren av virkesfordon. Med CTI kan man alltid köra med ett däcktryck och det blir då avsett mindre vibrationer, enligt Skogforsk studie.

Med CTI (Control Tire Inflation) kan en verkstadsman däcktryck justera efter aktuella väg- och lastförhållanden. Detta skapar förutsättningar för att köra med låg höghet. En annan fördel med CTI är att däckens inbyggda omställning kan tas till vara under hela transporten från lastplats till utsläpp och tillbaka. Utan CTI måste man välja däcktryck efter lastförhållanden och vägen. Det gör att föraren har ett stort antal däck.

Närhet på ett däck med snett och kappning för att kunna se däcktrycket under färd. I studien användes däcktryck för virkesfordon 800 kPa vid "Landings lastet" och 650 kPa för "Gravering lastet". För detaljer se Skogforsk 800 kPa vid "Landings lastet" och 650 kPa för "Gravering lastet".



Study by Granlund (2004):

Vibration was measured on 5 road stretches. When the TPCS cut in, the seat vibration intensity was reduced by 8 % on average.

Greatest improvement was obtained with unladen truck on a potholed dirtroad, still allowing relatively high speed.

Very low improvement in paved highway sections without potholes but much long wave unevenness.

However, the study did not quantify the transfer of vibration as function of vibration frequency (roughness wavelength x speed).

Roadex IV demo on vehicle-driver vibration

Demo's in Highland, northern Finland, Norway & Sweden.

Reproducing the case study in 2007 from the Beaver Road 331:

1. Measuring truck drivers daily vibration exposure, $A(8)$, and comparing to the Action Value 0.5 m/s^2 .
2. Measuring spine compression, S_{ed} , caused by jolts at severe bumps, and comparing to the 0.5 MPa stress limit in the ISO 2631-5 standard.
3. Relating truck roll & lateral buffeting to non-uniform road edge deformation (undesired Rut Bottom Cross Slope Variance).



Photo: M Risberg

Roadex IV vibration studies in the Highland

The test vehicle will be a “wagon & drag” timber haulage truck from Ferguson Transport fitted with tyre pressure control system (TPCS).

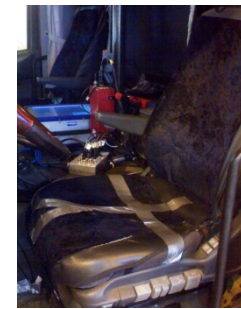


The vehicle also used as a standard vehicle when the TPC is switched off. Test route from forest to the Kilmallie Sawmill at Corpach, Fort William. The national organisation “Transport Scotland” will collaborate for the part of the haulage route on the A82 national road.

Highland study on TPCS vibration isolation

Objective:

To further evaluate the benefits of tyre pressure control systems on the transfer of vibrations from the tyre footprint to the driving seat.



The study will quantify the transfer of vibration as function of vibration frequency (roughness wavelength x speed).

Effect of winter time megatexture to be investigated with a TPCS truck on the Beaver Road 331 in Sweden.



Photos: G Eriksen, F Lindström & P Granlund