Minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration)

Grammer AG
Seating Systems
Alexandra Polster
Research & New Technology

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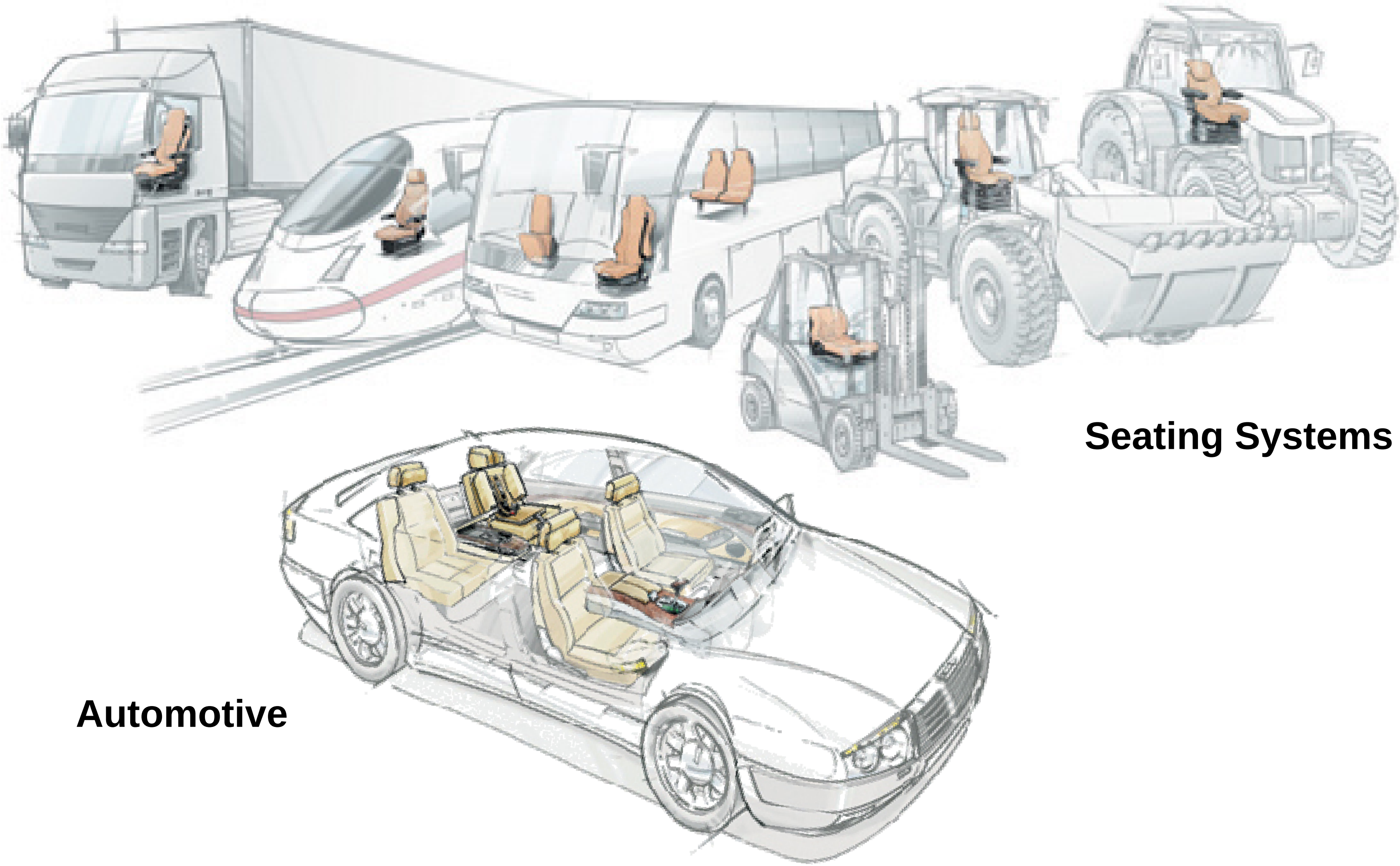
DIVISIONS GRAMMER AG



PRODUCTS OF SEATING SYSTEMS

Driver seats for construction machines: Actimo

Driver seats for tractors: Maximo Evolution

Driver seats for forklift trucks: Primo XL

Driver seats for trucks: Kingman

Passenger seats for coaches: Gran Turismo

ICE passenger seats

AGENDA

- **Description of Whole body vibration**
- **Health effects from exposure to WBV**
- **EU Directive 2002/44/EC**
- **How to identify risks**
- **How to minimize risks**

DEFINITION WHOLE BODY VIBRATION WBV

- Transmission of vibration into human body
- Operating a self-propelled moving vehicle

WHOLE BODY VIBRATION (WBV)

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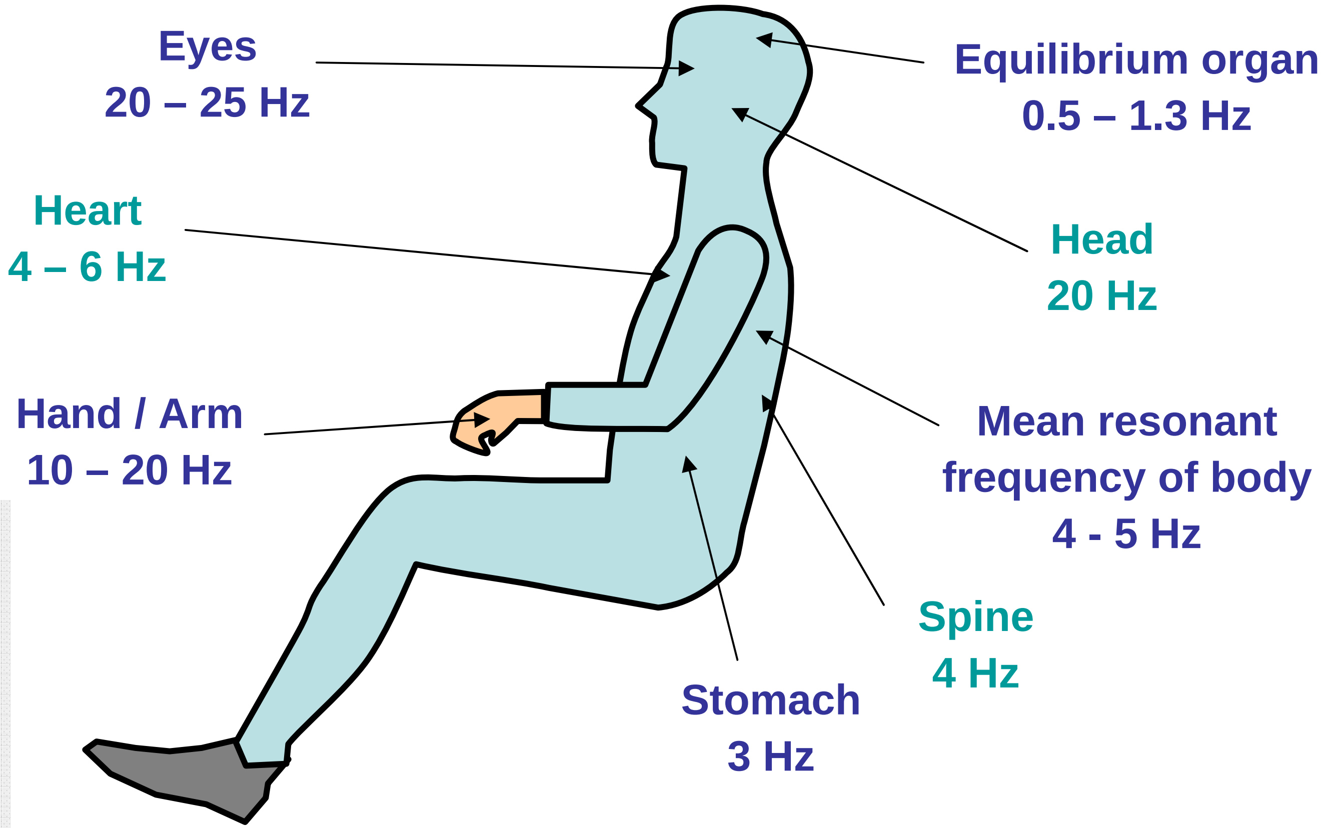
- Identified as an ‘Environmental Stressor’ in 1920 - 30s
- Exposure to WBV can cause negative health effects; either physical or mental
- WBV negative health normally manifests itself as Low Back Pain (LBP)
- Pre-existing LBP (for whatever reason) can be aggravated or an attack triggered by WBV exposure
- Many other medical symptoms can be associated with WBV exposure:
  - Headache
  - Lower task ability
  - Muscle tension
  - Blurred vision
  - Tiredness

THE PROBLEM OF WHOLE-BODY VIBRATION

WBV energy is exacerbated due to resonance

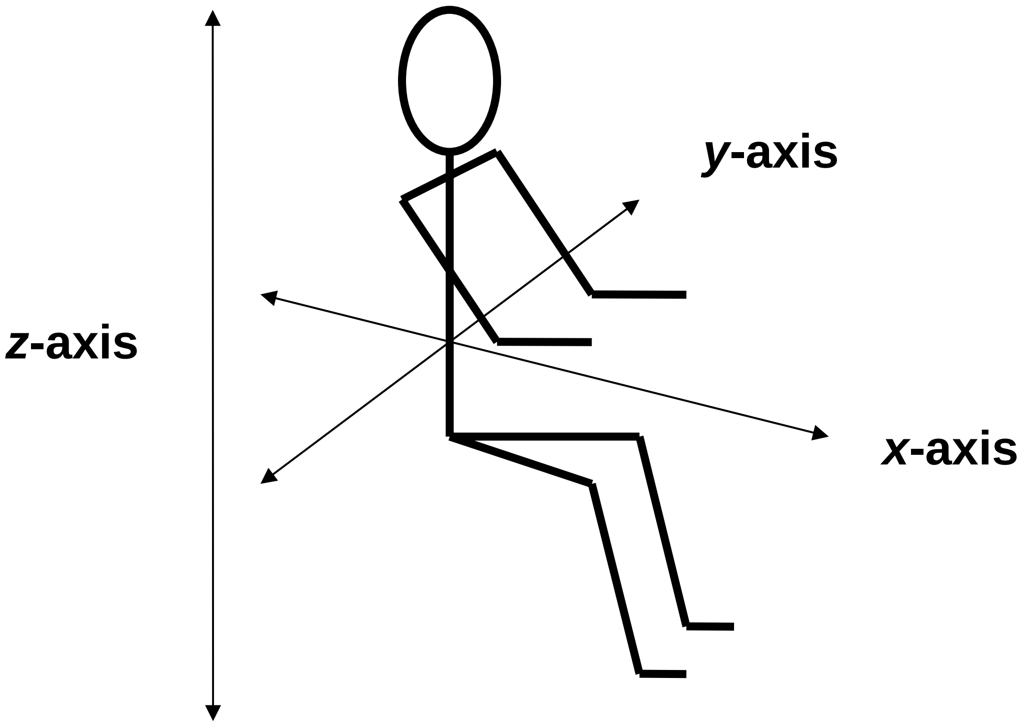
- All mass has a ‘resonant frequency’ (Human Body)
- Oscillatory energy is absorbed by body mass when WBV frequency matches the body’s natural frequency



Problem: resonant frequencies of vehicles are close to resonant frequencies of diff. body members and organs

HOW WBV ACTS UPON THE HUMAN BODY

Whole-body Vibration can act on the human body in any direction



Source: ISO 2631 (1997)

- z-axis = vertical, upwards perpendicular to the floor
- y-axis = lateral, from side to side, perpendicular to (forwards or backwards) direction of travel
- x-axis = longitudinal, from front to back, along the (forwards or backwards) direction of travel

SELF-PROPELLED MOVING VEHICLES

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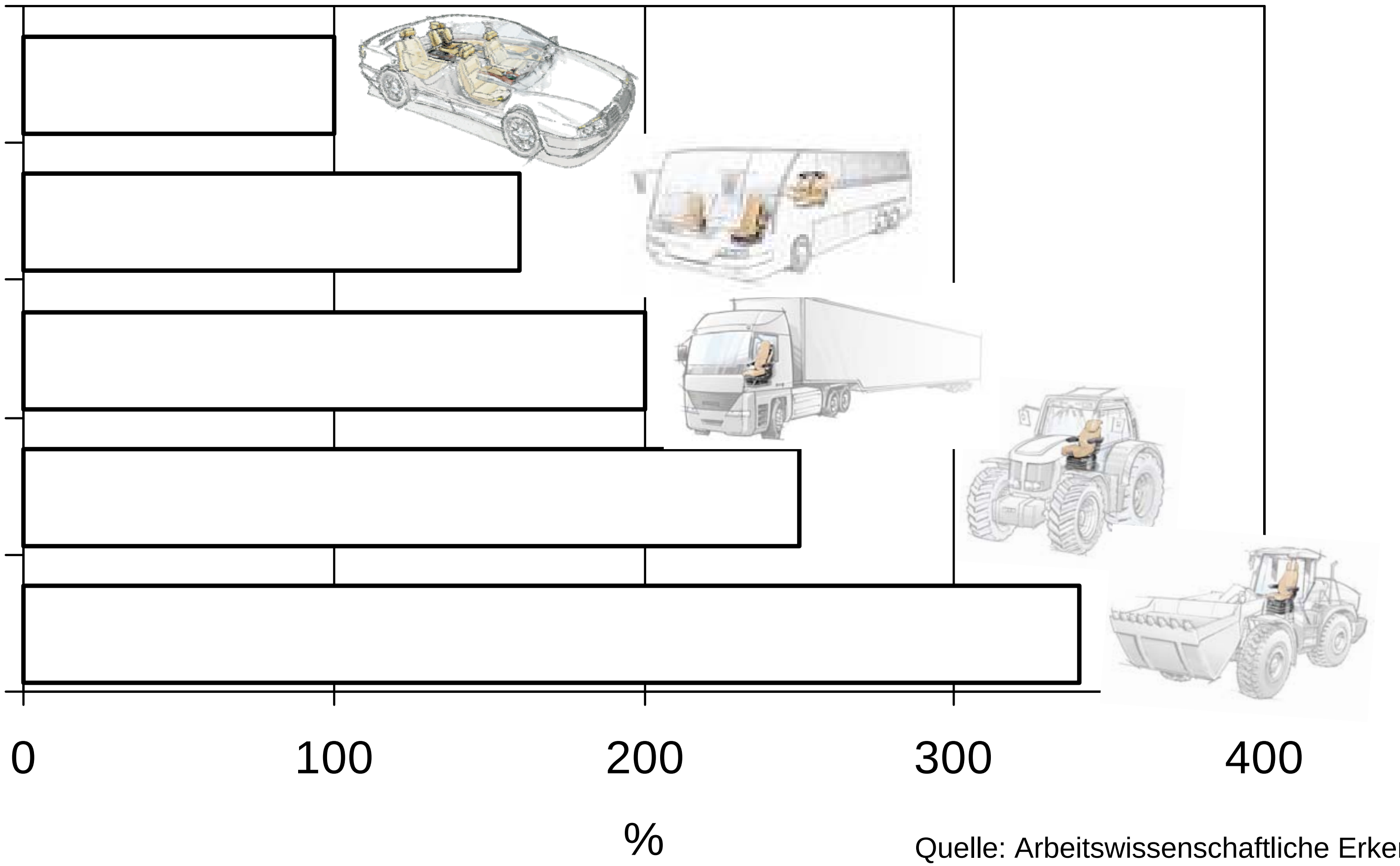
Relative vibration exposure of different types of vehicles



Quelle: Arbeitswissenschaftliche Erkenntnisse Nr. 32, Schwingungsminderung – Fahrersitze 3, Bundesanstalt für Arbeitsschutz, 1987

VIBRATION EXPOSURE

Number of people exposed to whole-body vibrations

estimations in Germany:

- about 15 Mio. people
- nearly 1,1 Mio. people exposed above $0.8 m/s^2$

EC DIRECTIVE 2002/44/EC - VIBRATIONS

Exposure limit values and action values Art. 3

(2) *For WBV*

daily exposure action value standardised to an eight-hour reference period shall be

0,5 m/s^2 or, at the choice of the Member State concerned, a vibration dose value of

9 m/s1,75

daily exposure limit value standardised to an eight-hour reference period shall be

1,15 m/s^2 or, at the choice of the Member State concerned, a vibration dose value of

21 $m/s^{1,75}$

(UK 1,15 m/s^2 / Germany 1,15 m/s^2 in x/y direction, 0,8 m/s^2 in z direction)

EC DIRECTIVE 2002/44/EC - VIBRATIONS

Assessment of workers exposure

Assessment of the level of exposure to vibration is based on the calculation of **daily exposure A(8)** expressed as **equivalent continuous acceleration** over an eight-hour period, calculated as the highest rms value or VDV of the freqeuncy-weighted accelerations, dtermined on three orthogonal axes

$$A\,(8)=\max[1{,}4*a_{wx},\ 1{,}4*a_{wy},\ 1\ a_{wz}]$$

ASSESSING WBV RISKS

- Estimation based on published information
  - Databases / health and safety guidance
  - Manufacturers' vibration data

- Considering
  - The specific machine
  - Specific working environment

If the exposure limit value may be exceeded :

- Measurement of the vibration

ASSESSING WBV RISKS

Setup for the vibration measurement in the vehicle

Accelerometers working in x-, y- and z-direction on the seat base and seat cushion

Data logger for acceleration measurement in the vehicle

The acceleration values must be measured on the seat in the vehicle under real working conditions !

ASSESSING WBV RISKS

Vibration Dosimeter™

- Easy to attach to the driver seat
- Continuously records vibrations (x,y,z) and calculates expsoure values
- Alerts operators if maximum permissive levels are reached or exceeded
- Employer can take appropriate measures (e.g. precise measurement by an authorized inspection agency, new seats, organisational measures …)

Control measures

Once the **exposure action value is exceeded** the employer shall establish and implement a programme of technical and/or organisational measures intended to reduce to a minimum exposure:

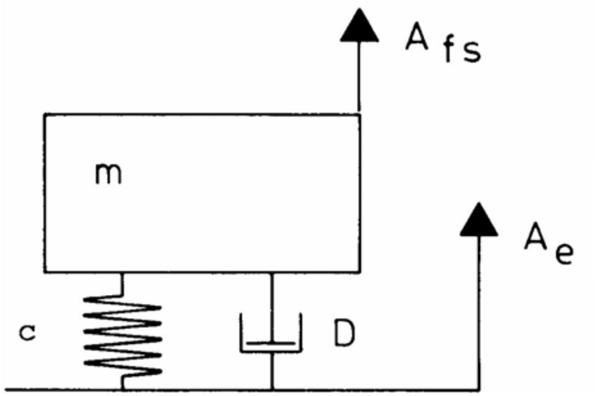
- Other working methods
- Choice of appropriate work equipment
- Provision of auxiliary equipment such as seats that effectively reduce WBV
- Maintenance programmes
- Information and training
- Limitation of duration

In any event, workers shall not be exposed above the exposure limit value!

Technical control measures – vibration isolation

MINIMIZING THE RISKS

Vibration isolation



Natural frequency of a spring- mass-system

$$\boxed{f_o = \frac{1}{2\pi}\sqrt{\frac{c}{m}}}$$

A_{fs} = amplitude of driver seat

m = mass of seat and driver

c = spring stiffness of suspension system

D = damper

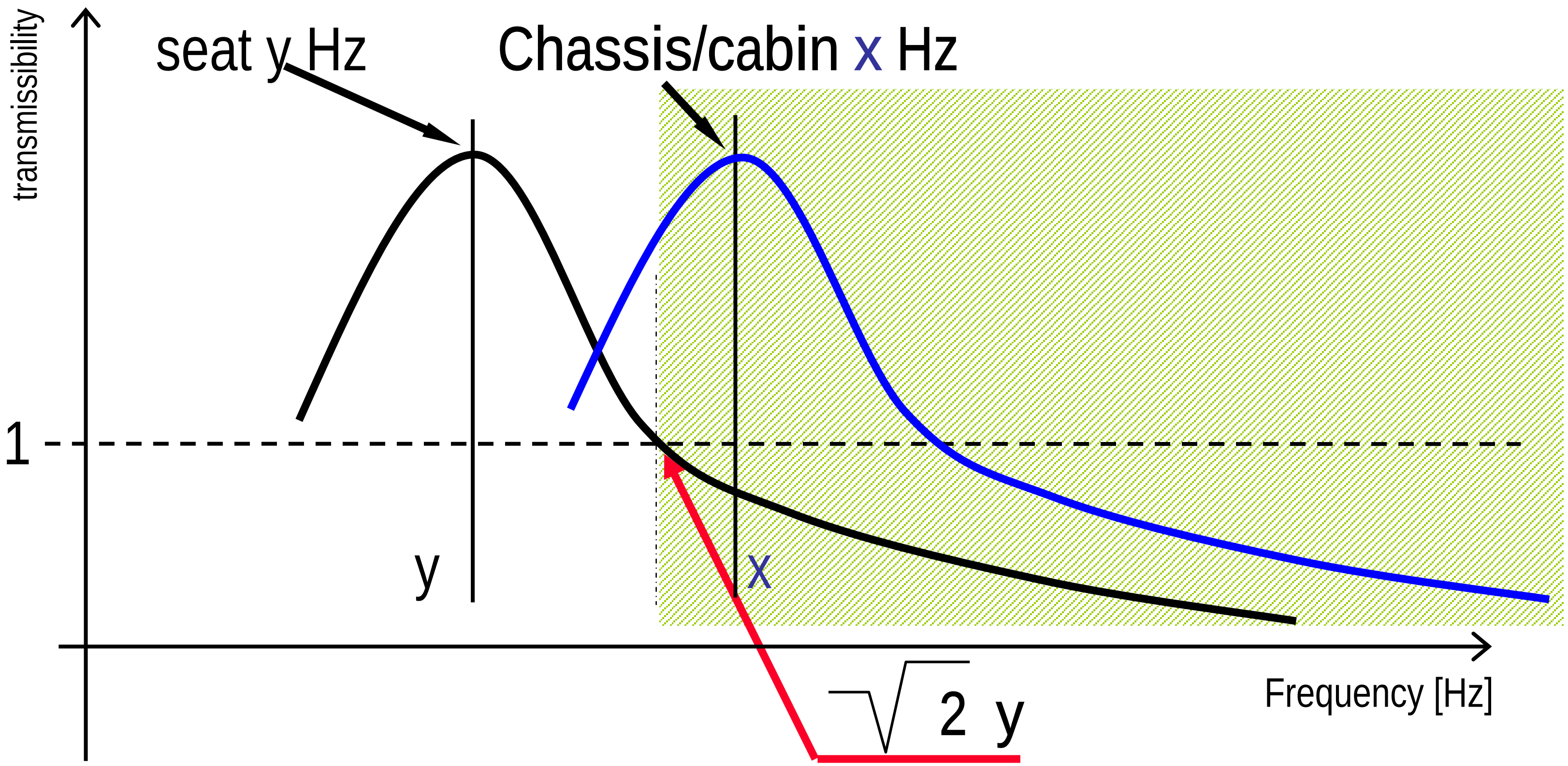
A_e = excitation cabin amplitude

f_e = excitation frequency

The suspended seat can be described as a spring-mass-system (simplified).

The natural frequency /eigenfrequency of a seat is proportional to $\sqrt{c/m}$.

Vibration isolation



A reduction in amplitude (attenuation) can only be achieved with frequencies higher $\sqrt{2}$ * seat natural frequency.

MINIMIZING THE RISKS

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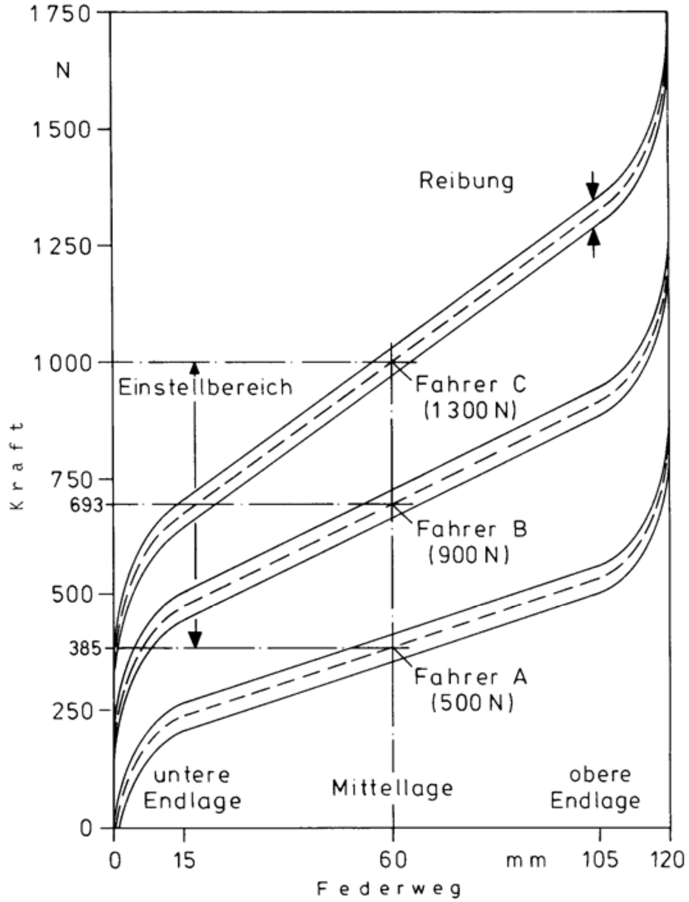
Vibration isolation - driver weight adjustment

$$f_o = \frac{1}{2\pi}\sqrt{\frac{c}{m}}$$

With this suspension system not only mid position is **adjusted** but also the **spring rate**. Thereby drivers with different weights can get the same vibration comfort.



Springcharacteristics of an air suspendet seat, shown for 3 different driver weights.

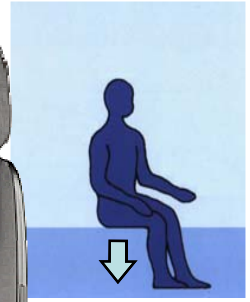
MINIMIZING WHOLE BODY VIBRATION

Technical measures

- Vehicle adjusted seat suspension systems (for example low frequency suspensions)
- Automatic weight adjustment
- Vehicle and vibration input (track, velocity …) adjusted systems (EAC)

Technical Solutions

Electronic fully automatic weight adjustment



Sit down and start!

- The weight adjustment is the essential ergonomic function in the seat for health care at the work place.

- Due to the sensor technology and electronics in the Actimo Evolution the seat is **fully automatically adjusted to the driver's weight**

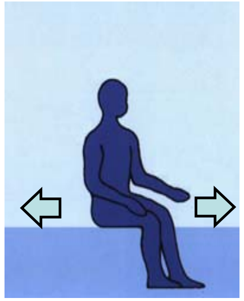
- This means securing of the optimal suspension travel, optimization of the sitting positions in view of security relevant and ergonomic aspects by suspension travel limitation (APS)

ACTIMO EVOLUTION

Optimized fore/aft suspension

The new suspension-damper-tuning
reduces horizontal vibrations in driving direction
caused by:

- Pitching of the vehicle at higher speeds.
- Assembly of various additional equipment.
- rough terrain



ACTIMO EVOLUTION

"Actimo Evolution in trend-setting design with new functions"

Active seat climatisation
Cooling or heating the seat for a comfortable sitting climate

Electronic weight adjustment
for the fully automatic adjustment and readjustment of the driver's weight

Improved vibration comfort
for optimal horizontal and vertical vibration reduction

New handling concept
for the intuitive handling of the seat functions by

- positioning,
- shaping,
- moving direction and
- feedback of the operating elements

TECHNICAL CONCEPT EAC

Definition of semi active or active suspension

$$\underbrace{m \cdot \ddot{x}}_{mass} + \underbrace{b \cdot \dot{x}}_{damping} + \underbrace{c \cdot x}_{spring} = \underbrace{F_{floor}}_{ex.force\_floor} + F_{control}$$

- **Passive suspension:**
  all our current products

- **Semi active suspension:**
  Sears „semi active" seat: **damping factor is controllable**, no external force is introduced

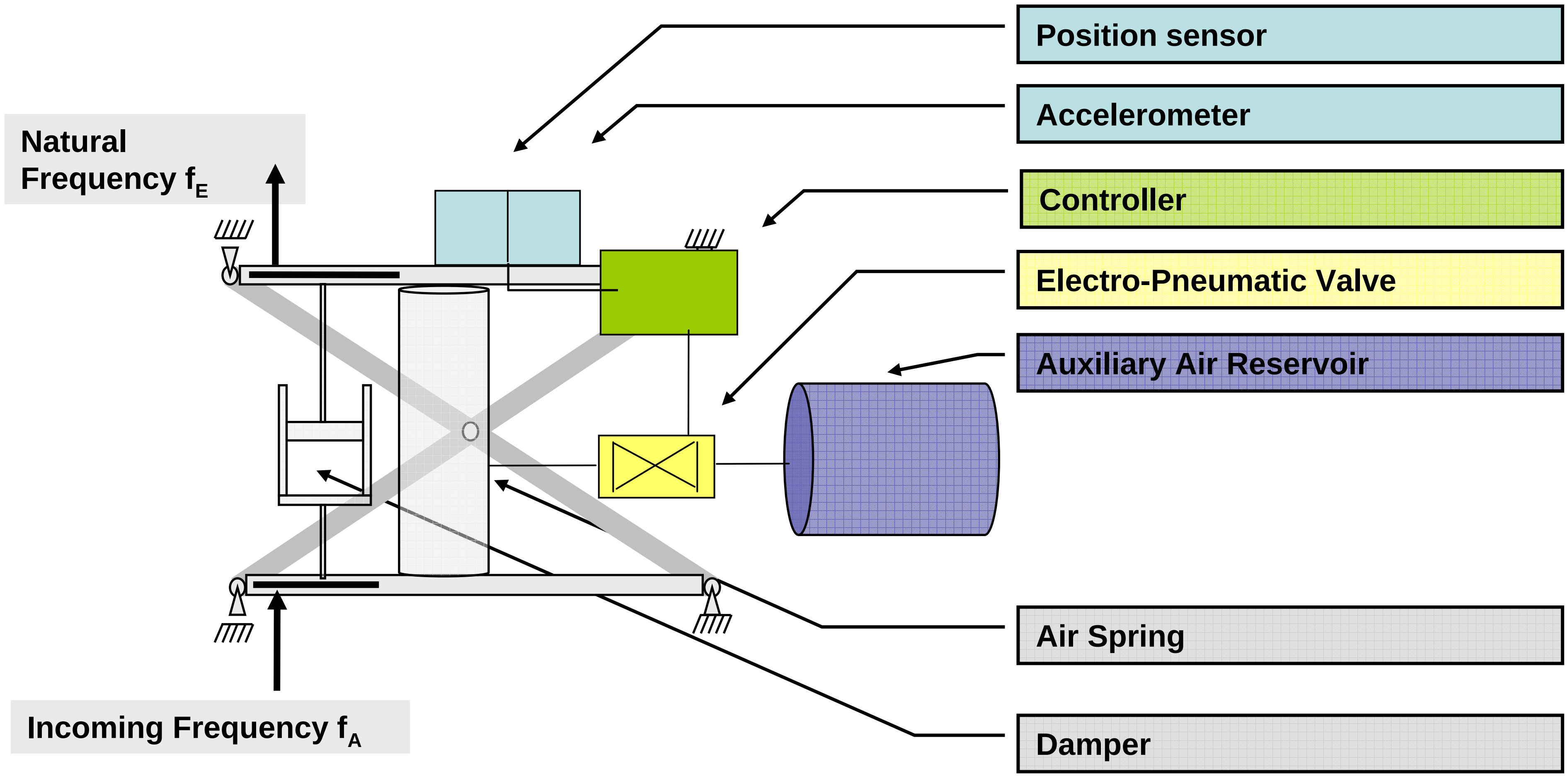
- **Active suspension:**

  - John Deere active seat:
    damping factor is controllable, **external force is introduced by hydraulic system** (control element is integrated in damper)

  - Grammer EAC spring rate is controllable, **external force is introduced by pneumatic system** (control element is integrated in air spring)

ACTIVE SEAT SUSPENSION EAC

EAC - Drawing - Overview



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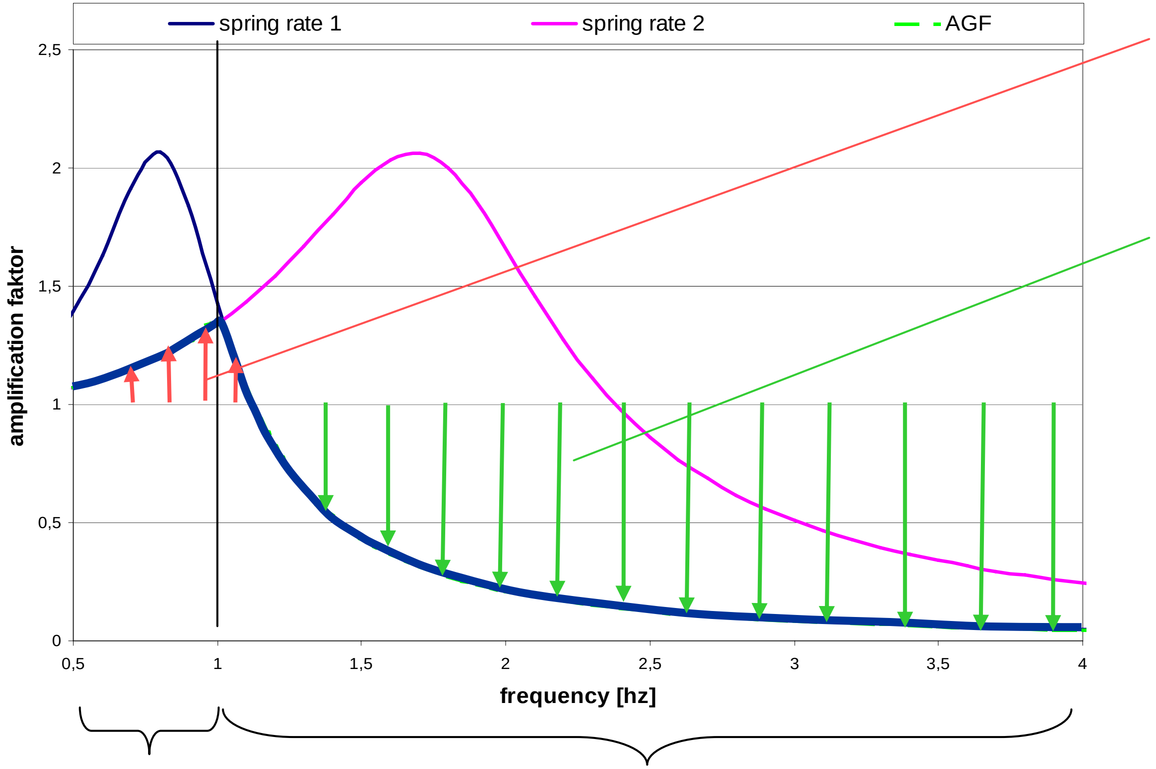
Transferfunction



Zone for low frequency incoming strokes

Zone for high frequency incoming strokes

Minimum of amplification of the oscillation up to 1,2 Hz

Maximum of reduction of oscillation from 1,2 Hz

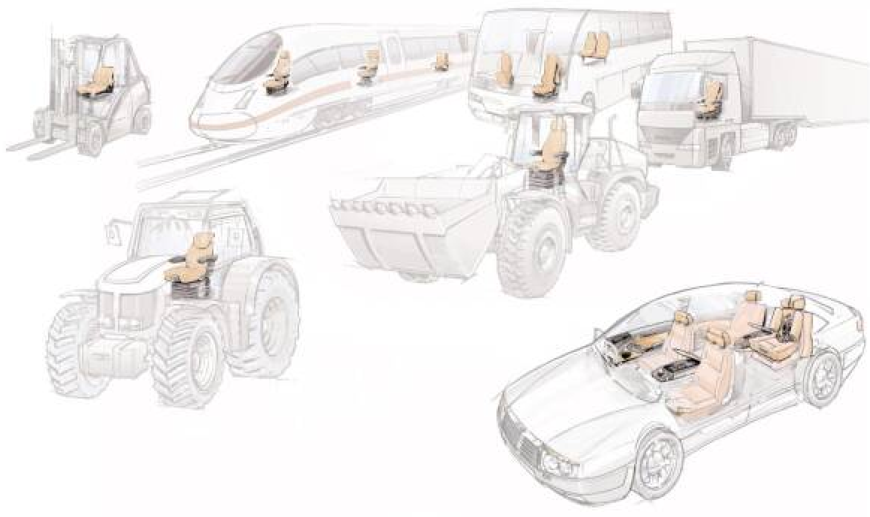
- Regulation of the air flow is changing the rate of air spring
- System selects the correct spring characteristic - depending on the frequency - which minimizes vertical seat top acceleration

ACTIVE SEAT SUSPENSION EAC

Advantages

- Electro-pneumatic, active controlled airspring as Plug & Play solution
- Possibility of installation in all kinds of offroad vehicles
- Adaption by parameter setting
- Automatic recognition of road and field mode
- Active electronic weight adjustment included

Thank you for your attention!



Alexandra.Polster@grammer.com