Single Axle Running Gears FEBA - a New Concept of Radial Steering

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DaimlerChrysler Rail Systems (Switzerland) Ltd, Winterthur

Contents

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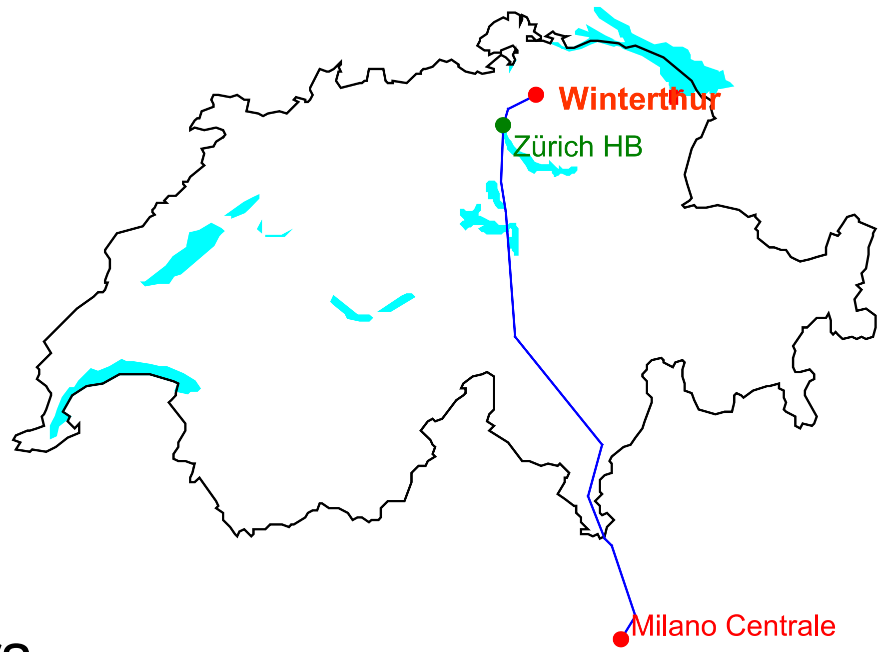
- Introduction of Adtranz Winterthur
- Principle of running gears FEBA
- Test vehicle
- Running tests (Video)
- Result of measurements
- Conclusions

ADtranz Winterthur

- Formerly: Swiss Locomotive and Machine Works Ltd
- Now : DaimlerChrysler Rail Systems (Switzerland) Ltd
- Product Unit: Bogies
- Specialisation: Bogies for locomotives and for regional traffic, single axle running gears



Development and Production of Railway Vehicles in Winterthur

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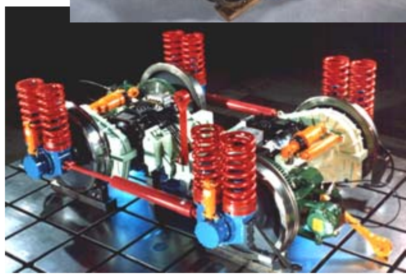
- Well known products:
  - Loco 2000 (Switzerland, Norway, Finland, Hong-Kong)
  - Bogies for regional traffic vehicles
  - Mountain rack and adhesion traction vehicles
  - Modern steam rack locomotives



From conventional bogie to coupled single axles FEBA

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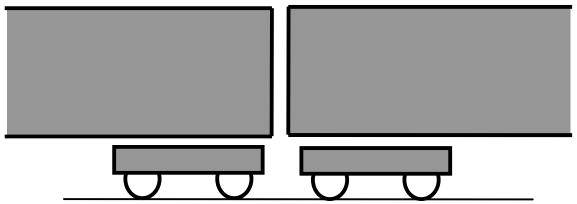
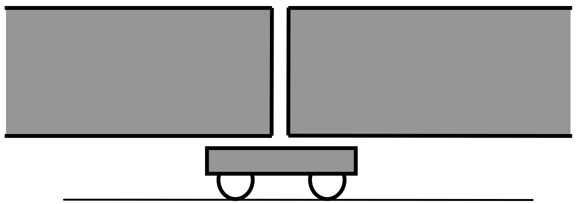
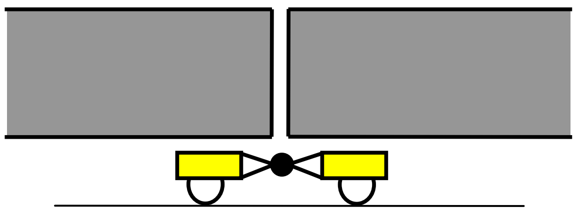
			Disconnect-ability	Weight
Bogie		**conventional**	+	-
Jakob Bogie		**conventional**	-	+
Coupled single-axles FEBA		**new!**	+	+

Decoupling of coupled single axles FEBA

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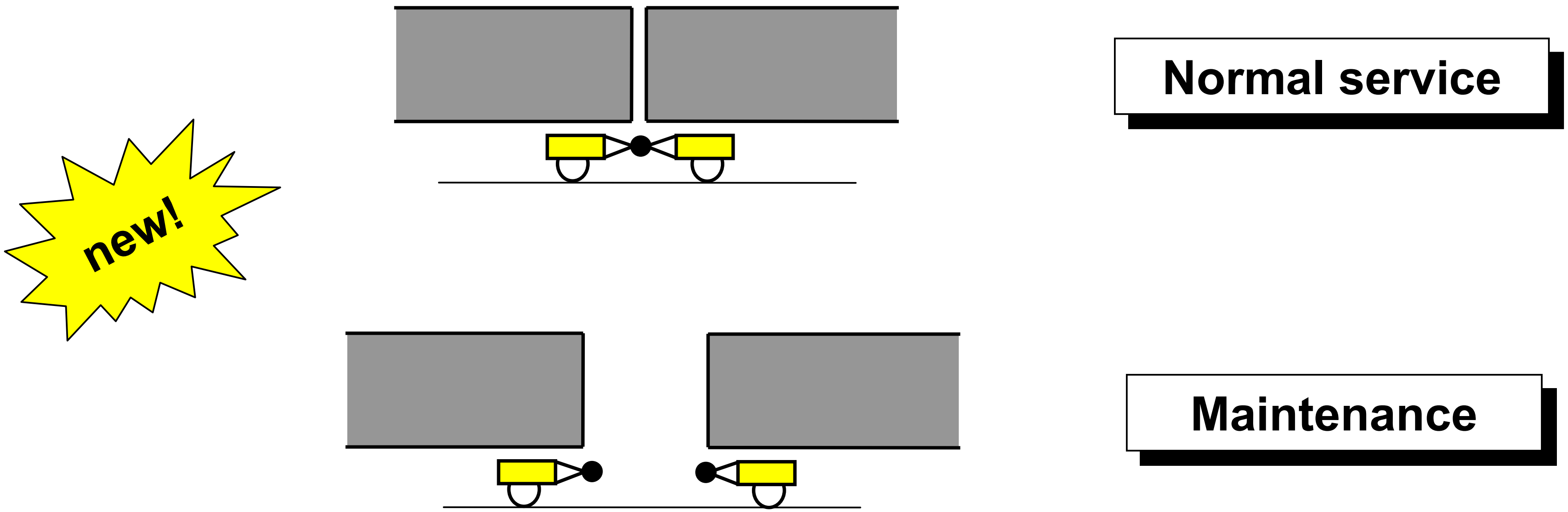

+ Decoupling is very easy
+ Separated coaches can be moved without subsidiary device

EMU NSB Class 72
Technical Data

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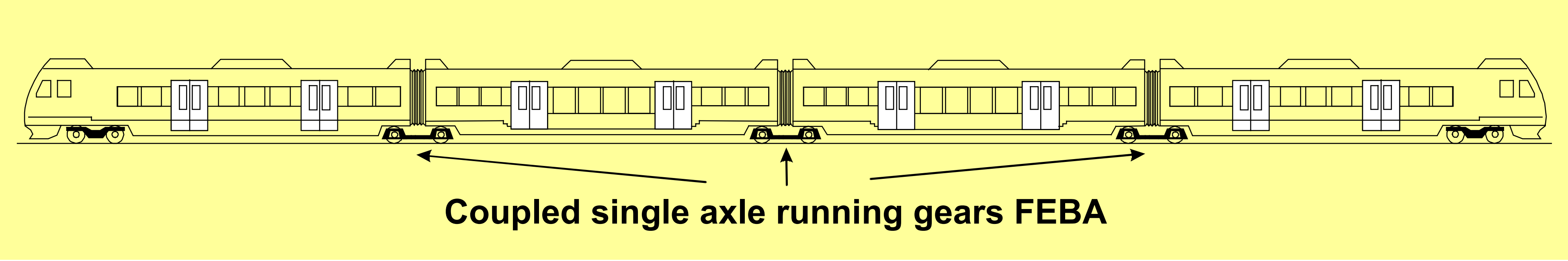

Total Length:	80 m
Vehicle Width:	3100 mm
Floor Height:	750 / 1210 mm
Max. Axle Load:	20,3 t
Traction Power:	2600 kW
Max. Speed:	160 km/h
Number of Seats:	300

FEBA Single Axle Running Gears
Principle

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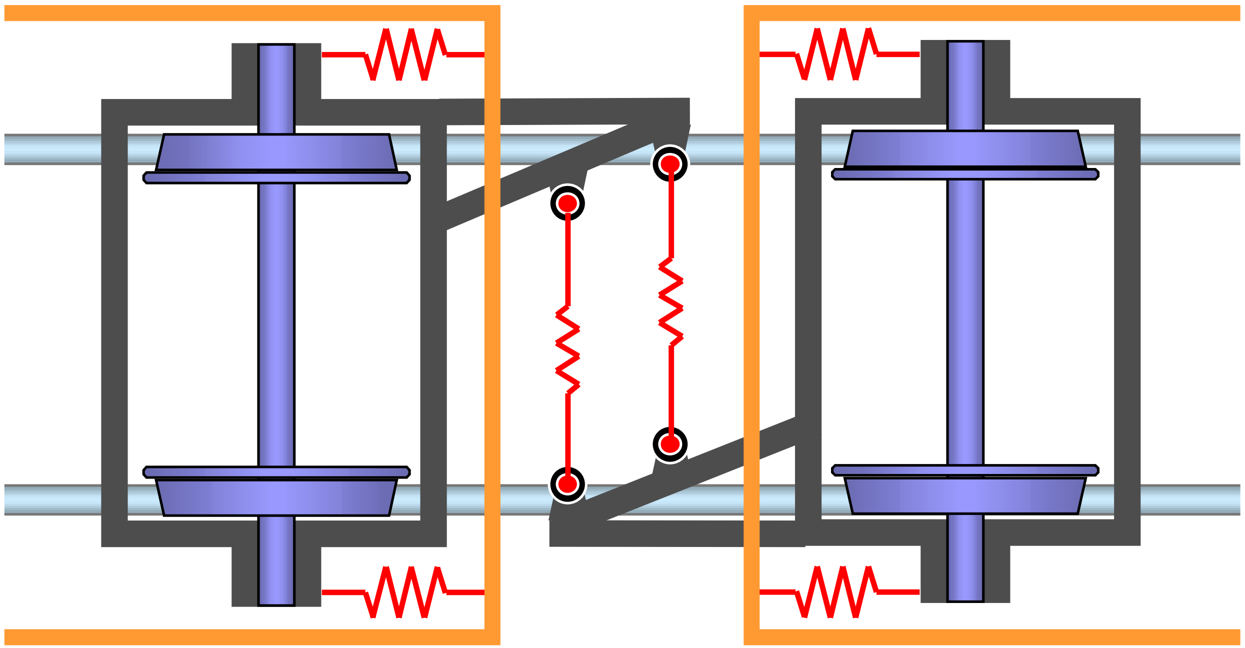
Flexibler **E**inzelachs **BA**ukasten

(Flexible Modular Single Axle Running Gear)



FEBA Single Axle Running Gears
Comparison with Conventional Concepts

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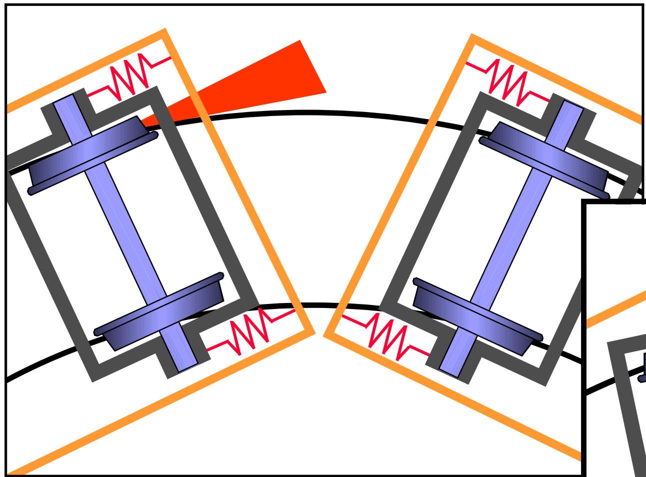
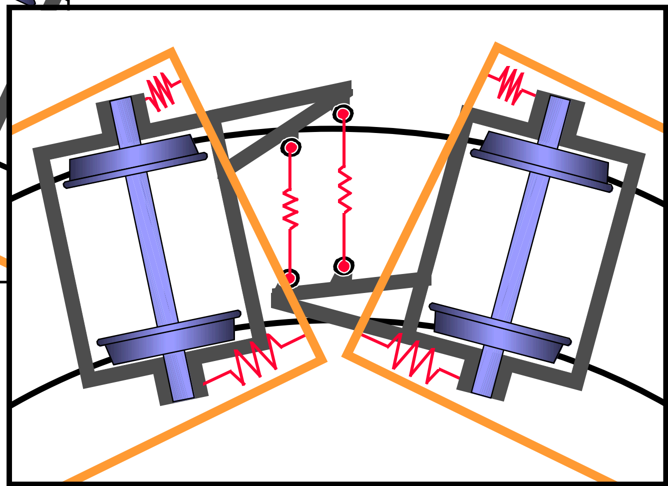
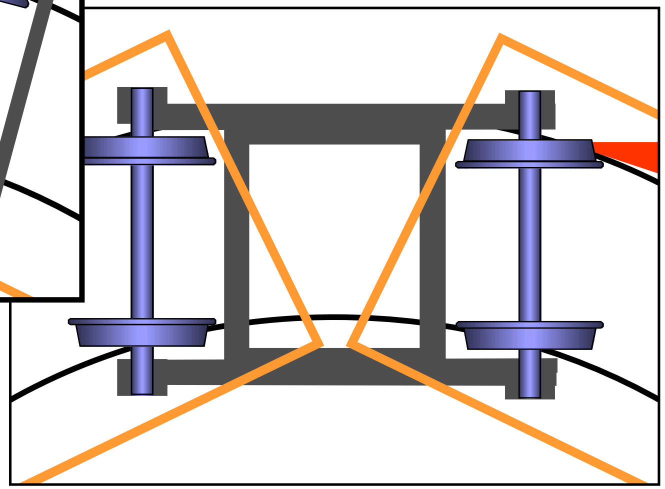
Single Axle Gear



Coupled FEBA Gears



Jakob Bogie



Test Vehicle for FEBA Running Gears
Running Gear Prototype

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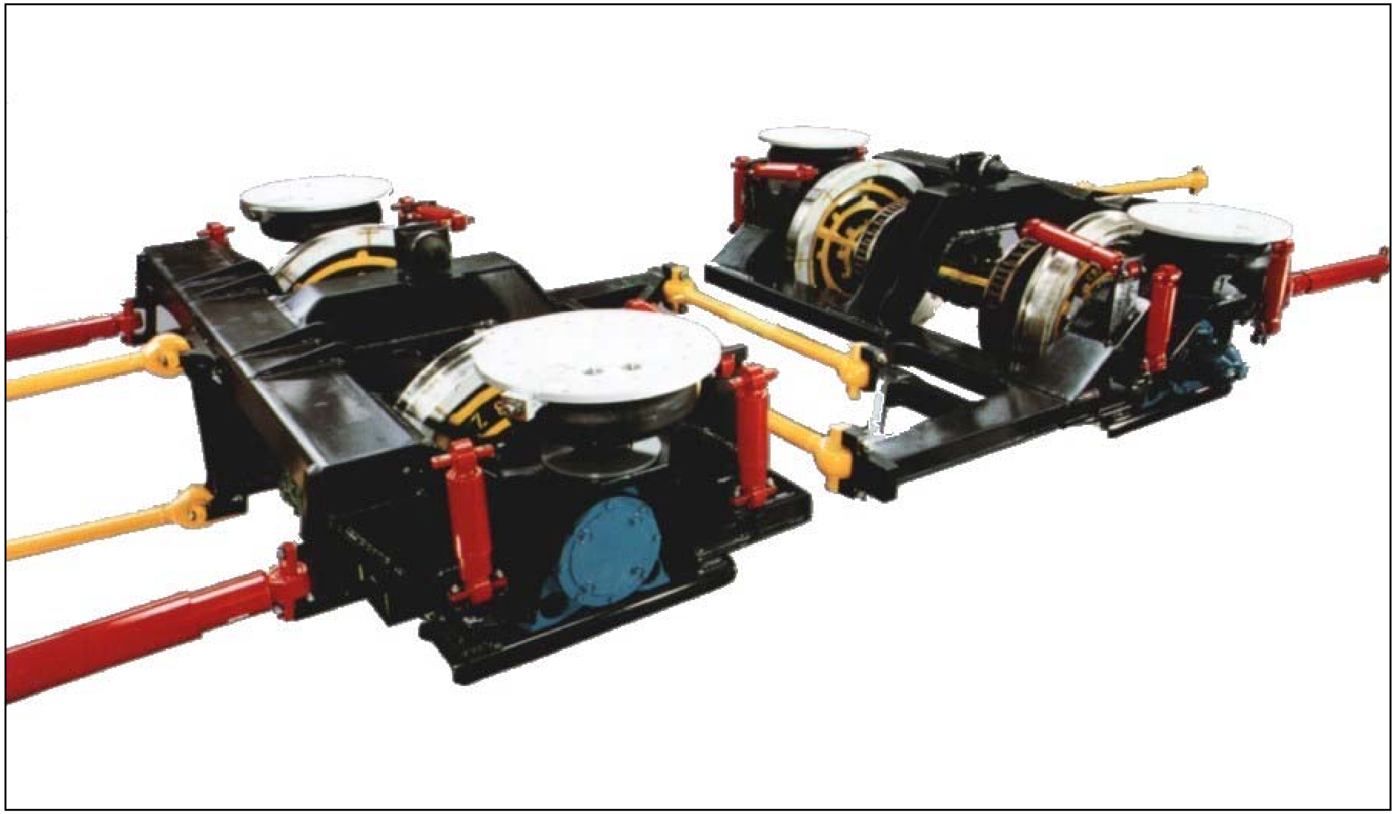

Test Vehicle for FEBA Running Gears
Design of Test Vehicle

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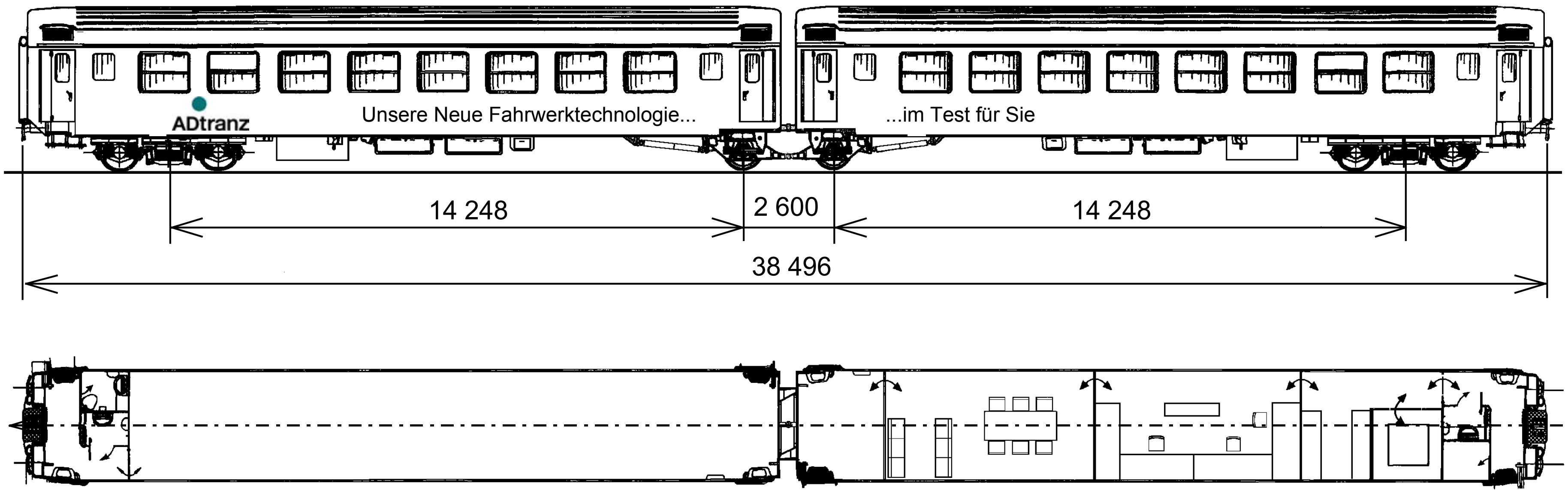

FEBA Single Axle Running Gears
Models for Vehicle Dynamics Simulations

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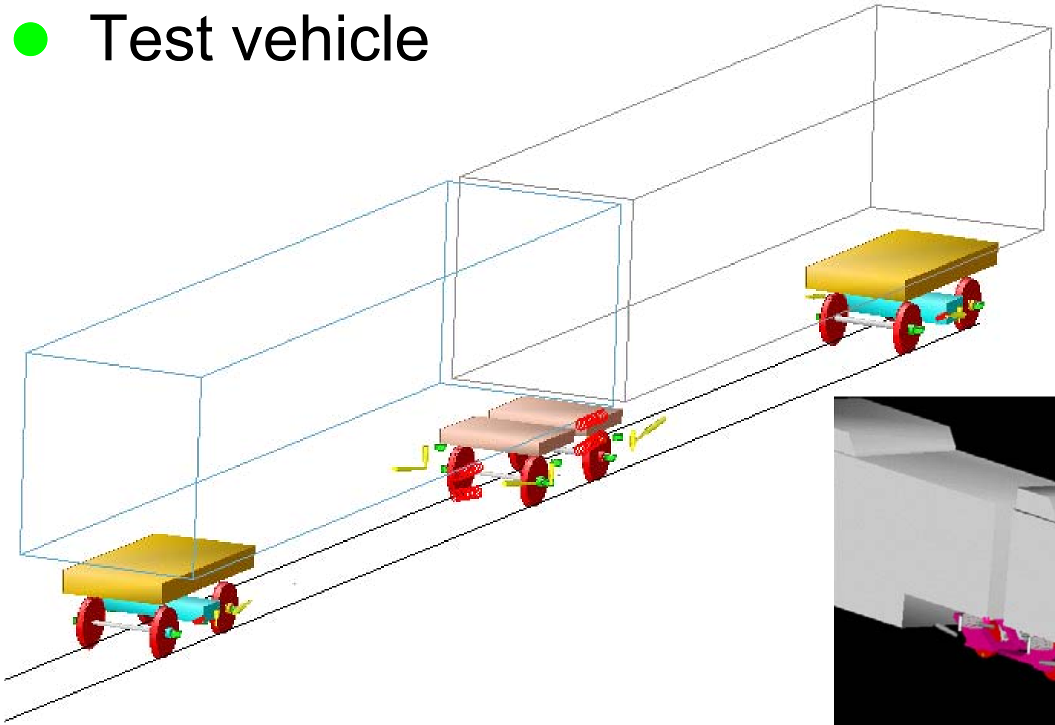
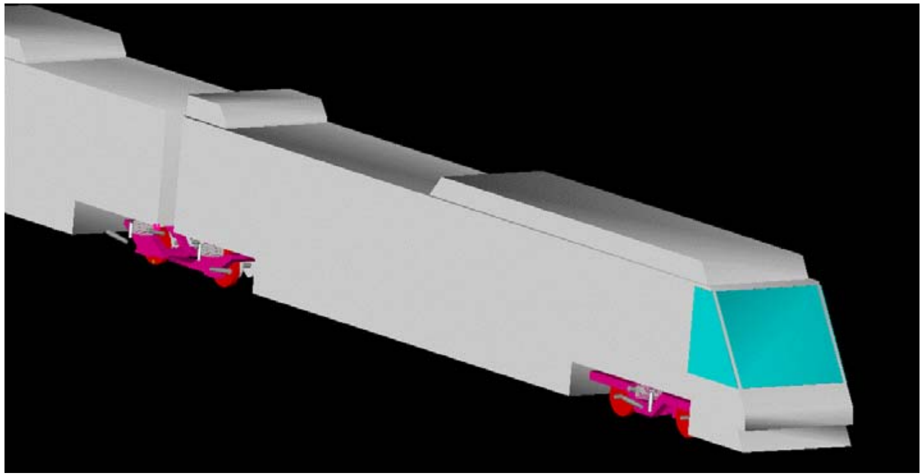
- Test vehicle



- NSB Class 72



FEBA Single Axle Running Gears Curving Simulation

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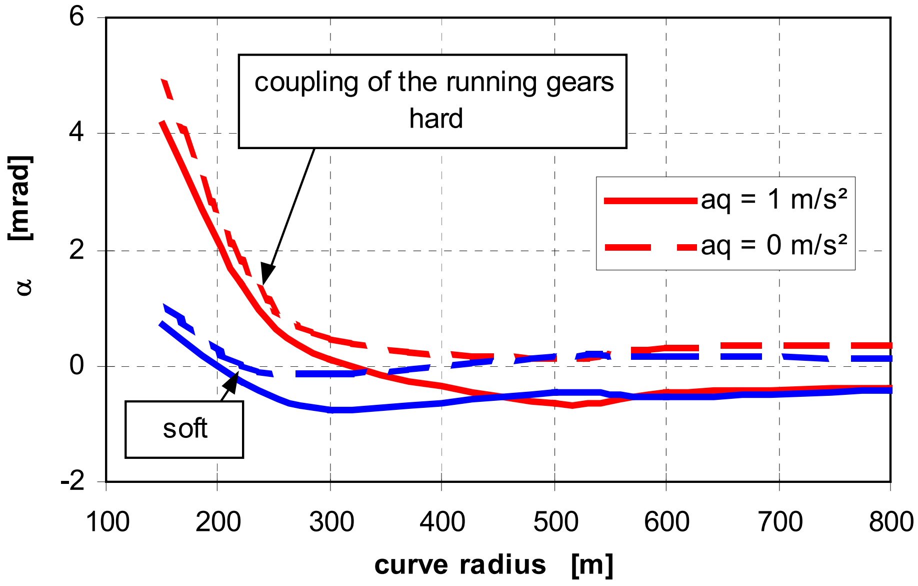
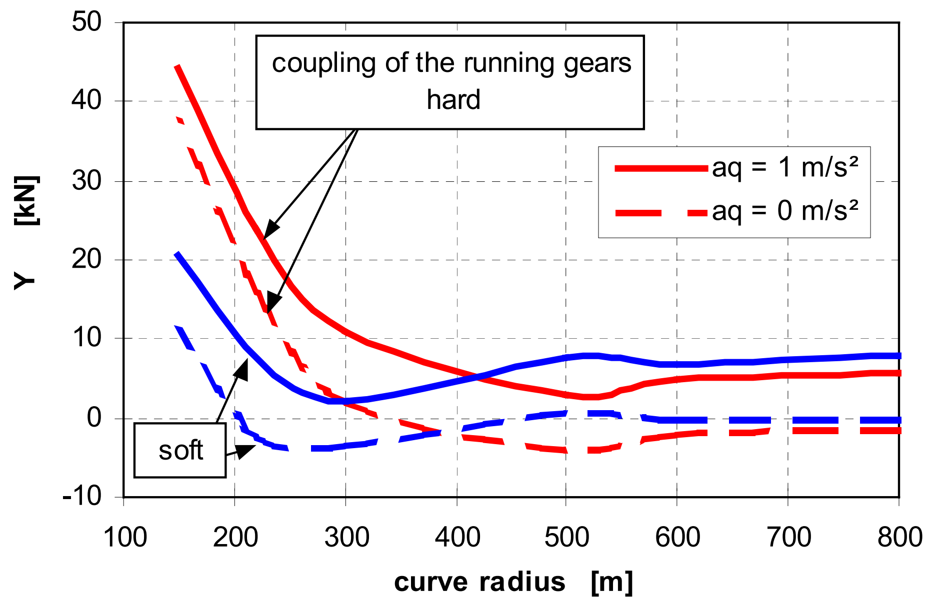
- Angle of attack



- Lateral wheel-rail force



Tests of Single Axle Running Gears FEBA
Test Purposes

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- **Vehicle dynamic tests**
  - Comfort
  - Running stability
  - Curving
- **Noise and vibrations**
  - Body noise transfer function
  - Outside noise
- **Test of assembly groups**
  - Load spectra of assembly groups
  - Air spring behaviour
- **Measurement of suspension displacements**
  - Displacement in primary and secondary suspensions
  - Roll angle of coach body

Tests of Single Axle Running Gears FEBA
Running Tests

- Contents of Video
  - Overview of products
  - Principle of single axle running gears FEBA
  - Development of FEBA
  - Test vehicle for FEBA running gears
  - Measurement of Eigenmodes
  - Measuring equipment
  - Tests up to 120 km/h
  - Tests up to 176 km/h

Test Vehicle for FEBA Running Gears
Parameter Variants

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- Primary suspension
- Air springs: Volume of auxiliary reservoir, orifice diameter
- Vertical dampers
- Lateral dampers
- Yaw dampers
- Coupling of the running gears
- Inter-car dampers

Test Vehicle for FEBA Running Gears
Measurements and Analysis

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- Comfort
- Running stability
- Wheel-rail forces
- Angle of attack, wheelsets radial steering
- Suspension displacements
- Roll angle coefficient
- Acceleration and noise transfer functions
- Outside noise
- Load spectra of assembly groups

Test Vehicle for FEBA Running Gears
- Test results -

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Presented results of the vehicle dynamics tests :

- running stability
- ride comfort
- curving
  - steering angle
  - quasi-static wheel-rail forces
  - dynamic wheel-rail forces

Test Vehicle for FEBA Running Gears
- running stability without 1 anti-yaw damper

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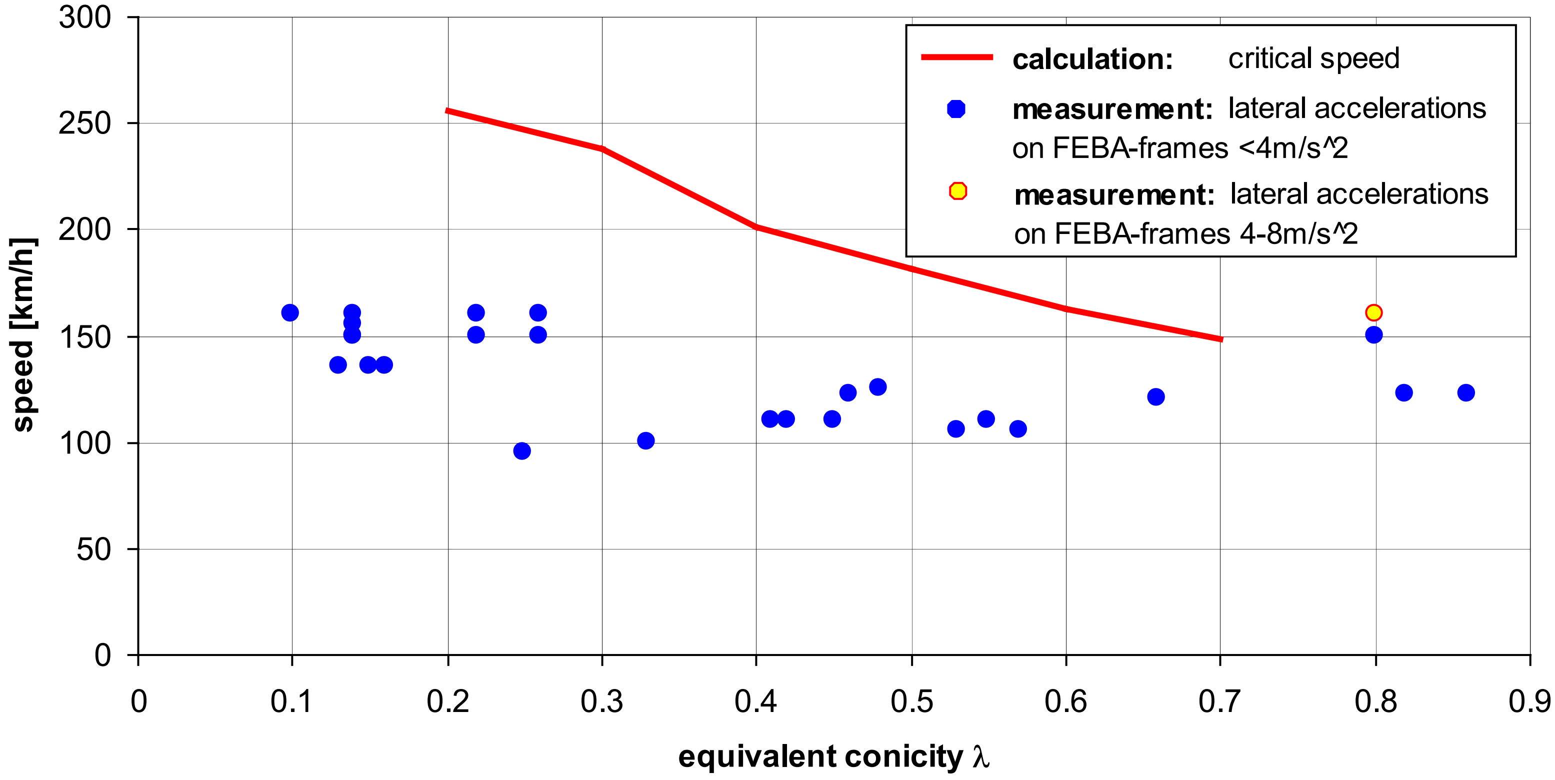

equivalent conicity calculated for measured rail profiles and wheel profile S1002 with linearization amplitude 3mm

configuration: basic, axle load 13t, 1 anti-yaw damper per FEBA dismantled

dry rails

Test Vehicle for FEBA Running Gears
- Measured Ride Comfort -

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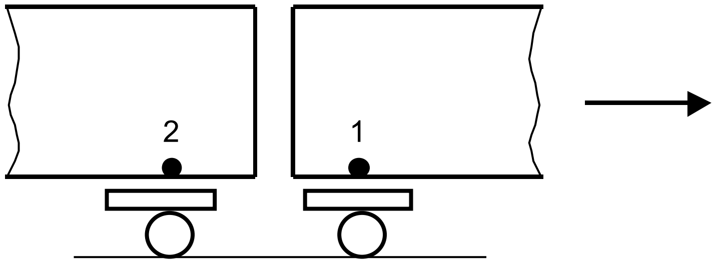

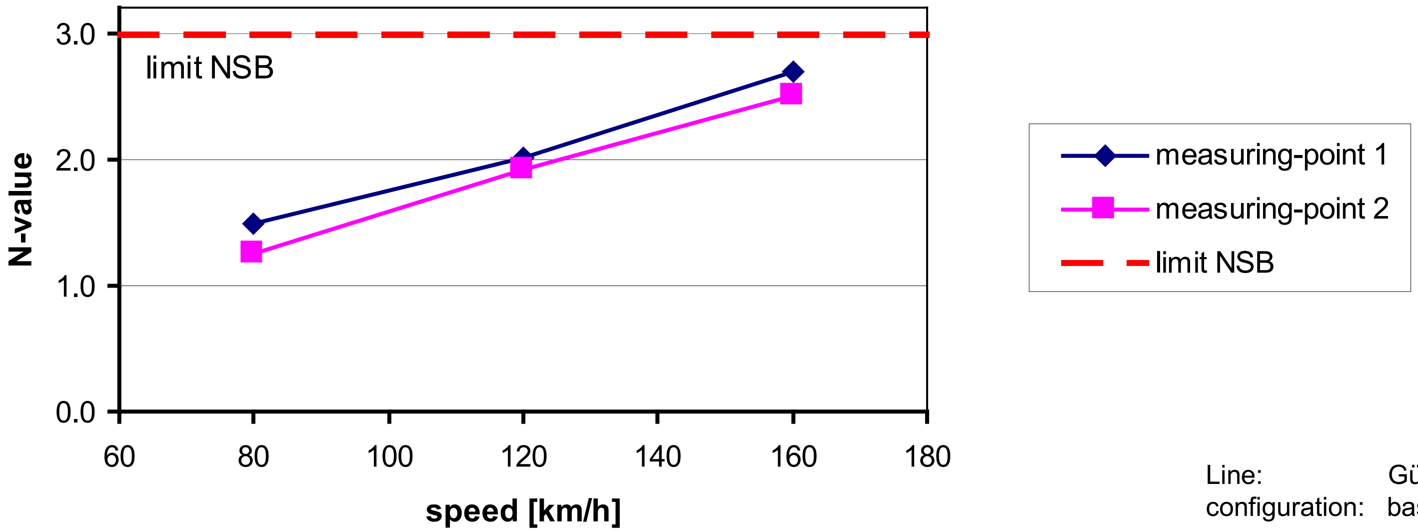

Line: Gümligen-Thun
configuration: basic

Test Vehicle for FEBA Running Gears
- steering angle on dry rails -

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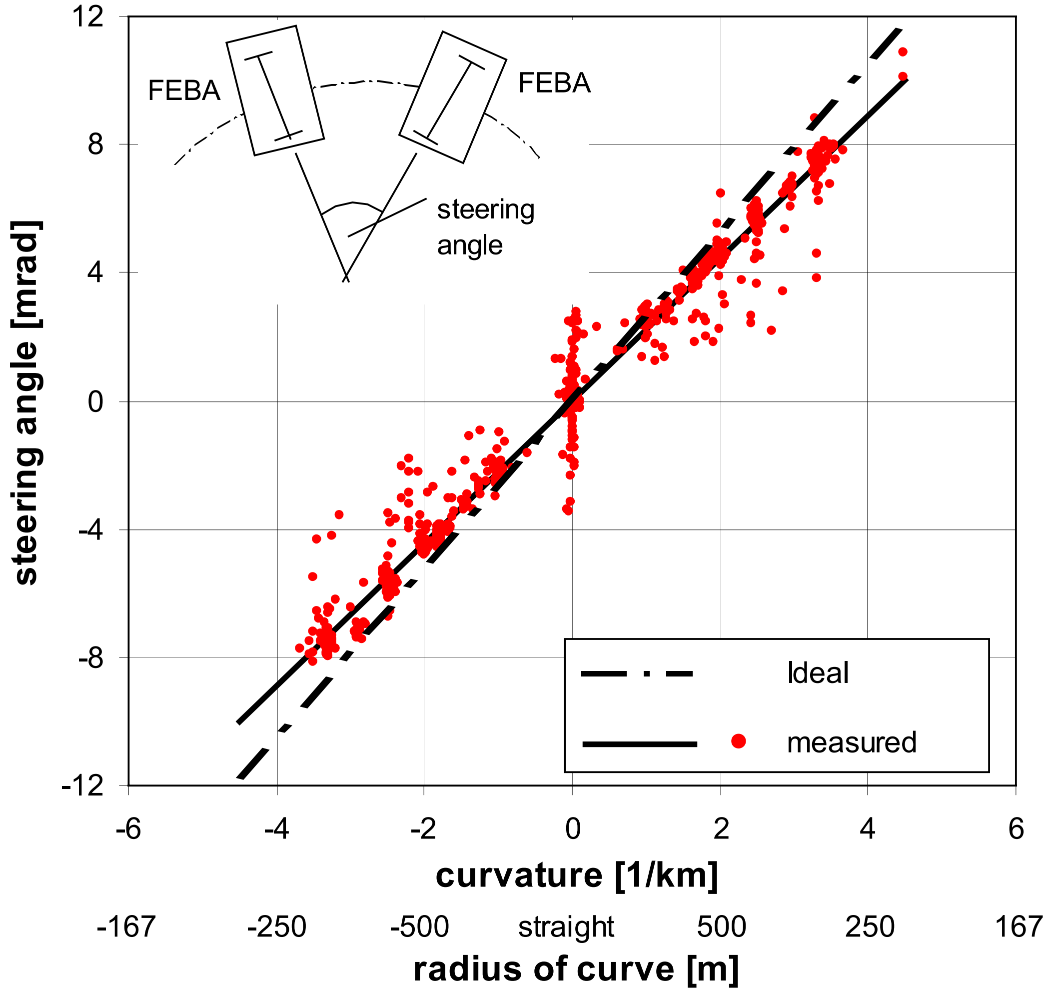

Line:	Oberwinterthur-Stammheim
speed:	70-110km/h
rails:	dry
configuration:	basic

Test Vehicle for FEBA Running Gears
- steering angle on wet rails -

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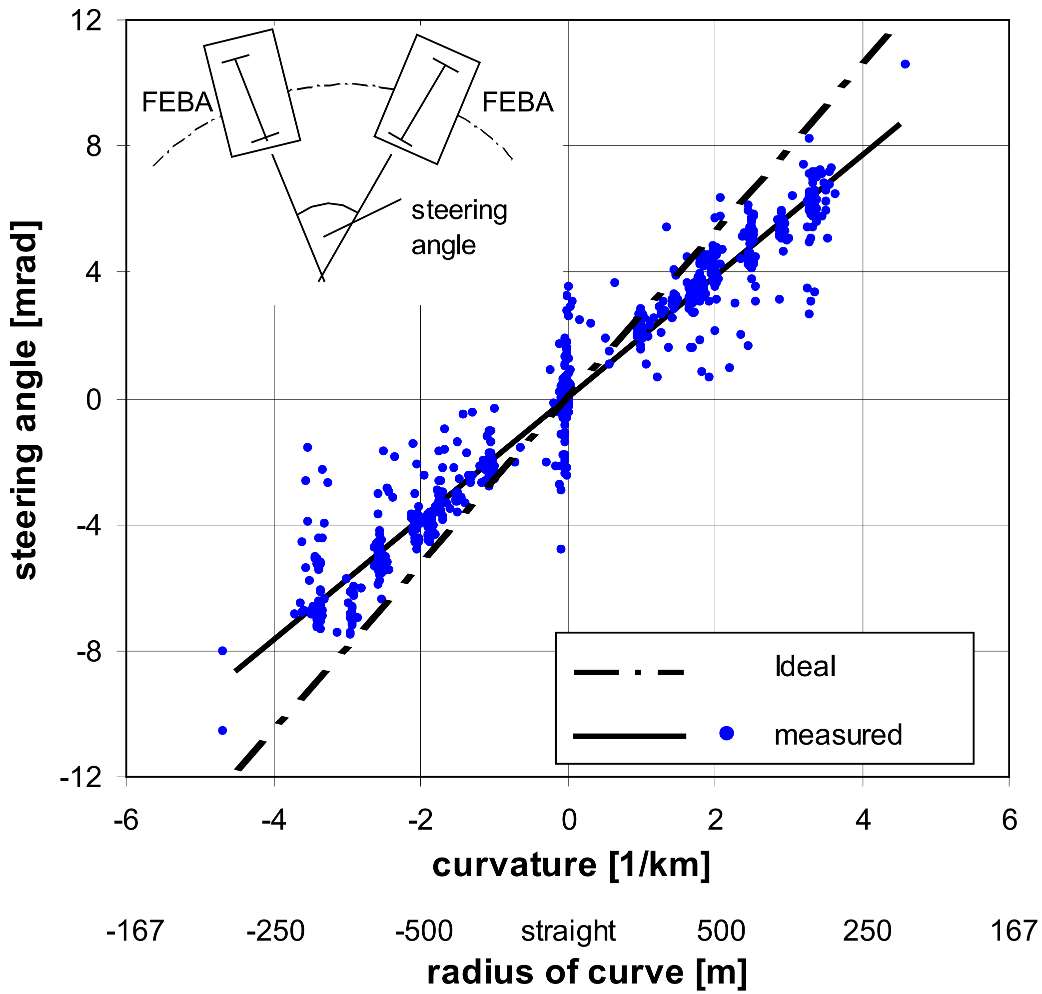

Line:	Oberwinterthur-Stammheim
speed:	70-110km/h
rails:	wet
configuration:	basic

Test Vehicle for FEBA Running Gears
Steering angle: dependency on weather conditions

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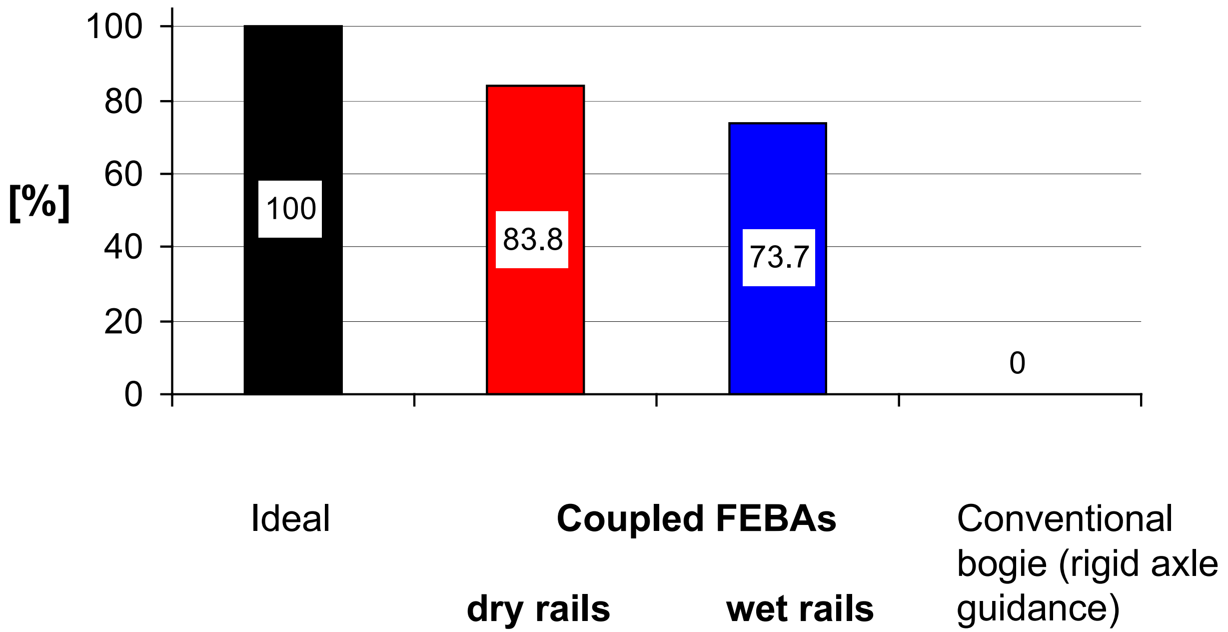
steering angle related to ideal steering angle



dependency on weather conditions

Test Vehicle for FEBA Running Gears
Steering angle: dependency on coupling stiffness

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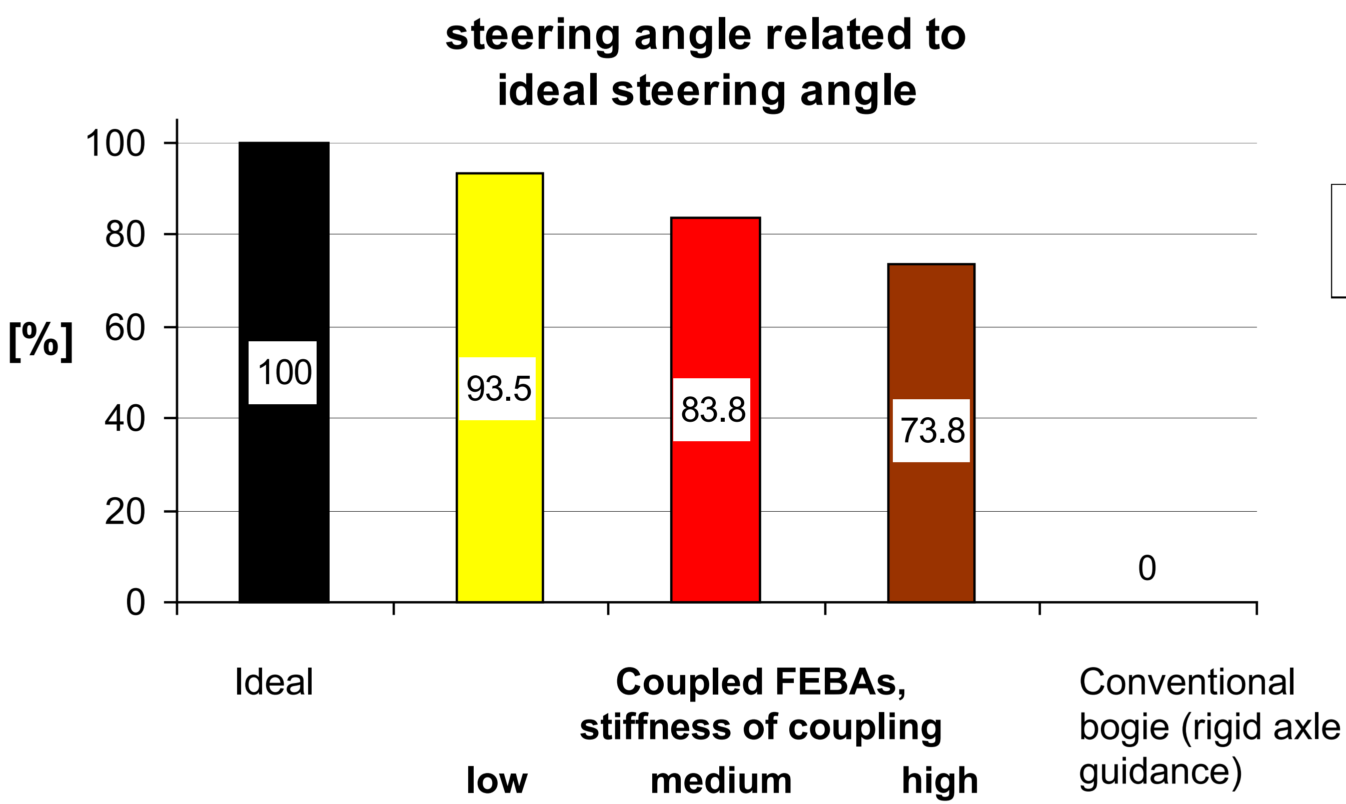

dependency on
coupling-stiffness

low = 25 kN/mm radial stiffness of the sphäro-links on the coupling-bars
medium = 50 kN/mm
high = 70 kN/mm

Test Vehicle for FEBA Running Gears
- Advantages of the good steering angle -

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The advantages of the good steering angle are:

- \+ little wear of wheels
- \+ little wear of rails
- \+ small risk, that wheels become out-of-round (wheels with polygons)
- \+ less noise in narrow curves
- \+ minimised wheel/rail-forces
- \+ less running-resistance and therefore
- \+ save of traction-force and energy

Test Vehicle for FEBA Running Gears
- Measured quasistatic lateral wheel/rail-forces -

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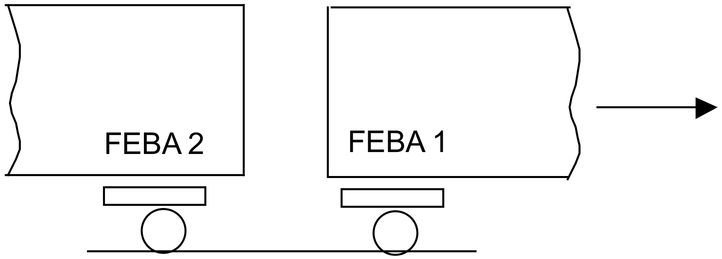
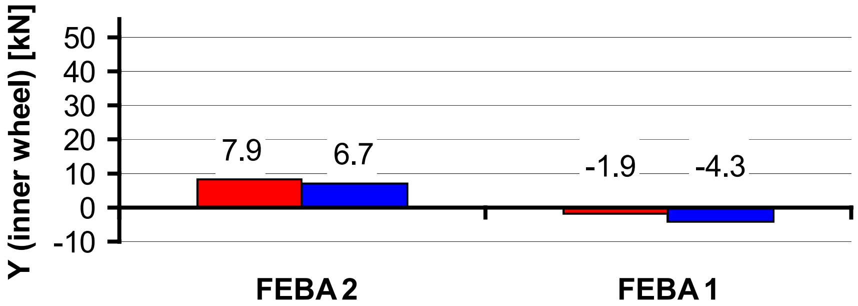
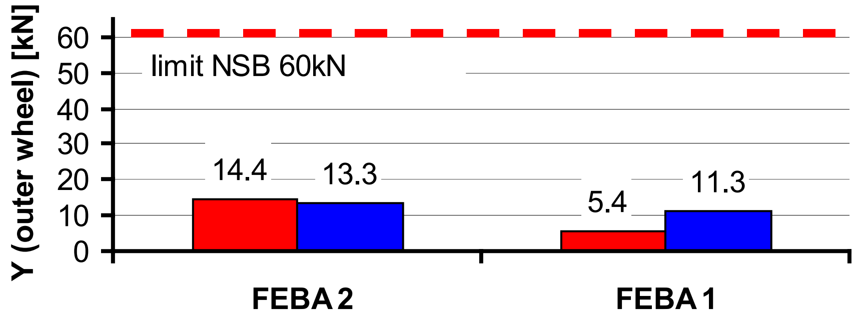
Axle Load 13t

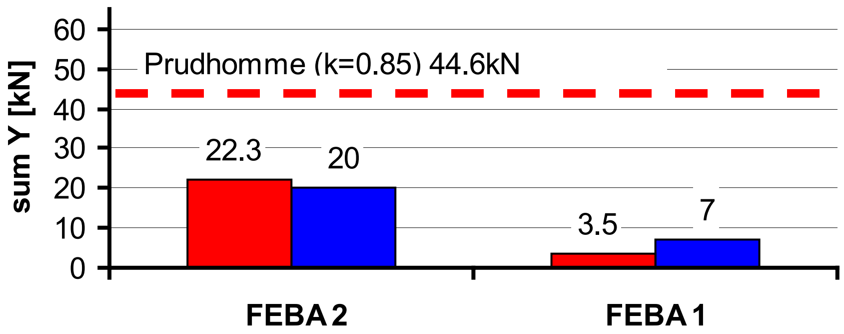


R=300m, bg=0.8m/s^2

R=400m, bg=0.8m/s^2







Line: Oberwinterthur-Stammheim

dry rails

positive forces are acting towards curving center

Test Vehicle for FEBA Running Gears
- Measured quasistatic lateral wheel/rail-forces -

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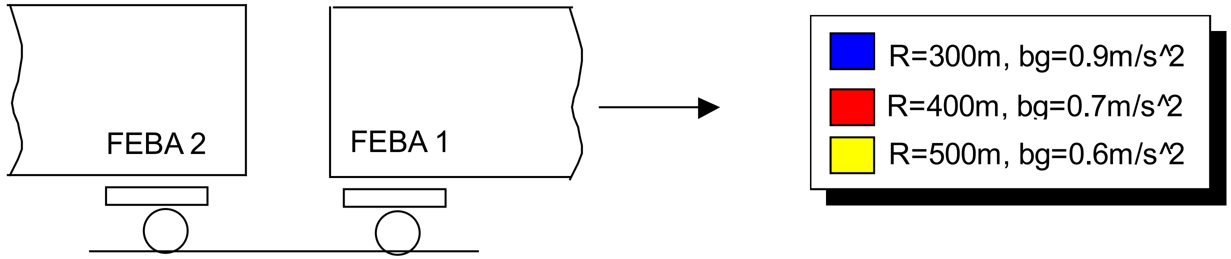
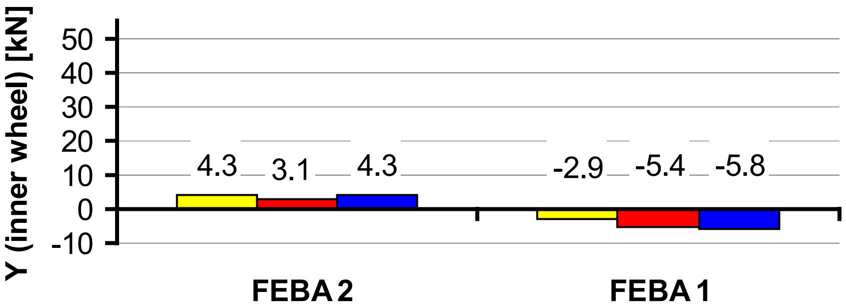
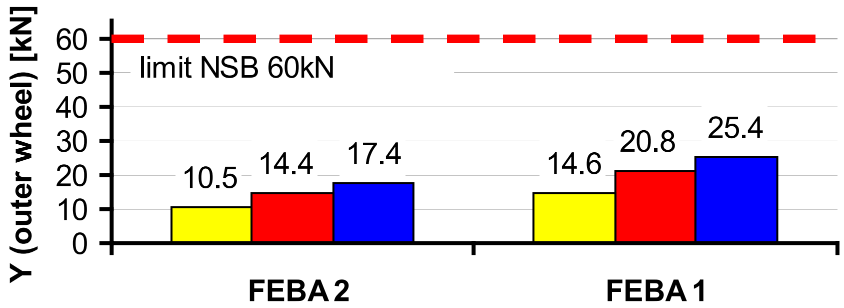
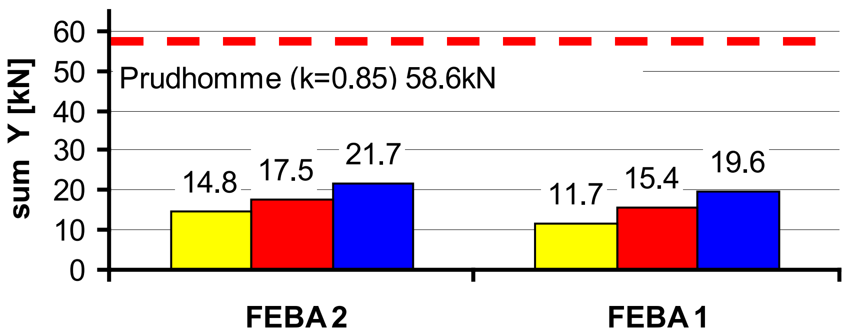
Axle Load 18t









Line: Oberwinterthur-Stammheim

wet rails

positive forces are acting towards curving center

Test Vehicle for FEBA Running Gears
Lateral forces: Comparison with calculation

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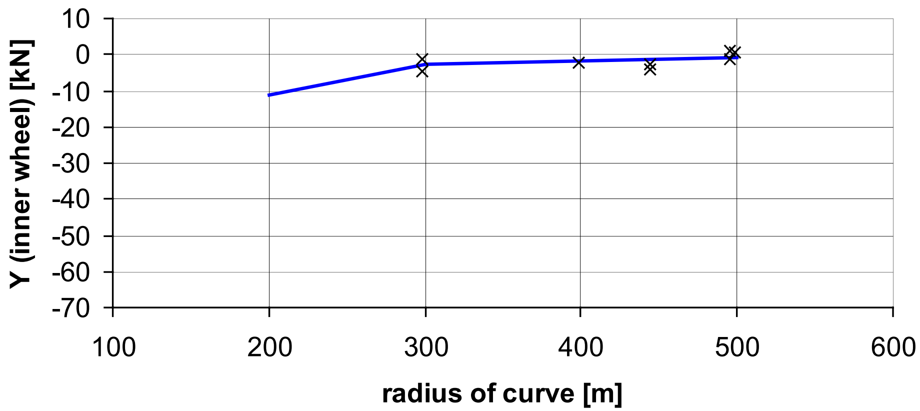

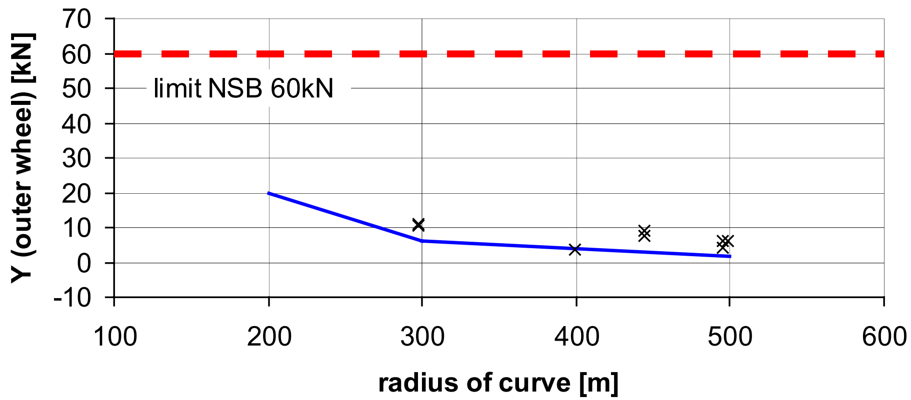

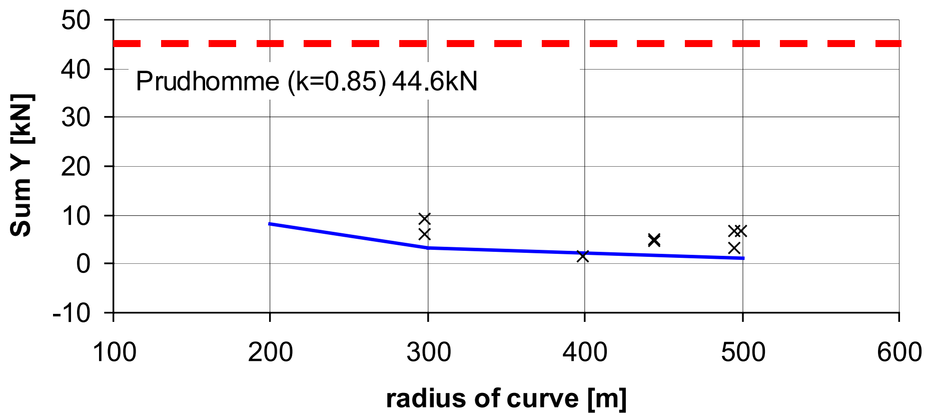

FEBA 1, axle load 13t

x measurement
bg=0.5m/s^2
dry rail

calculation
bg=0.5m/s^2
creep-force coefficient 0.3

Test Vehicle for FEBA Running Gears
- Measured quasistatic lateral wheel/rail-forces -

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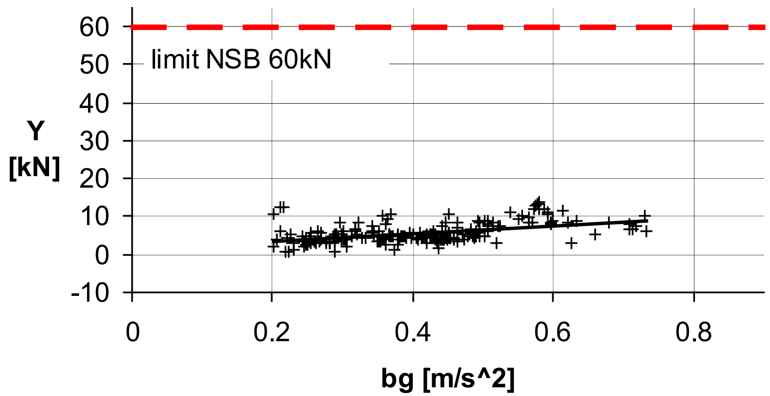
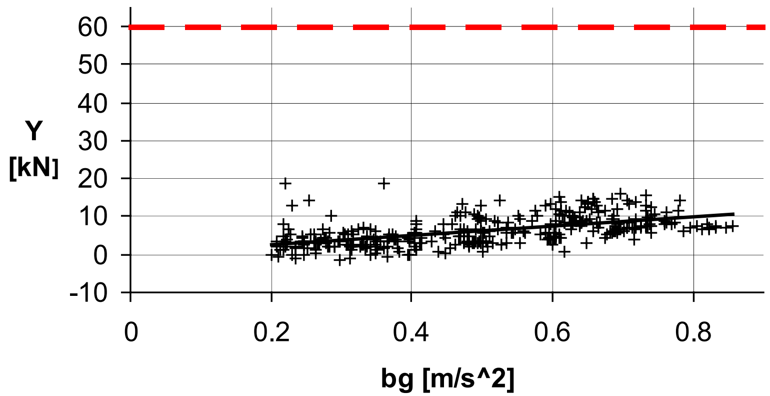
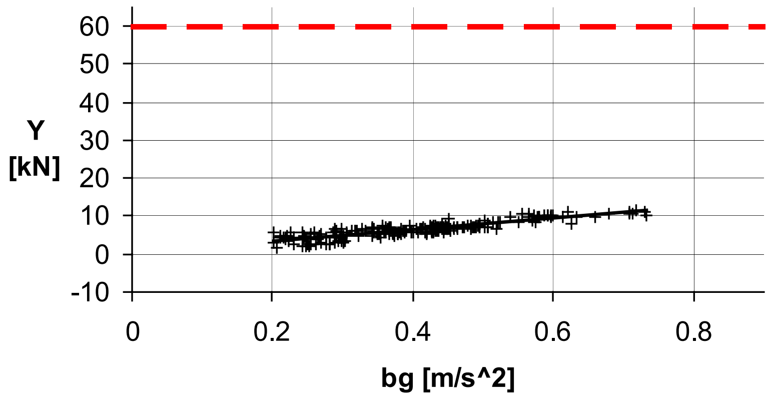
left wheels | axle load 13t | right wheels

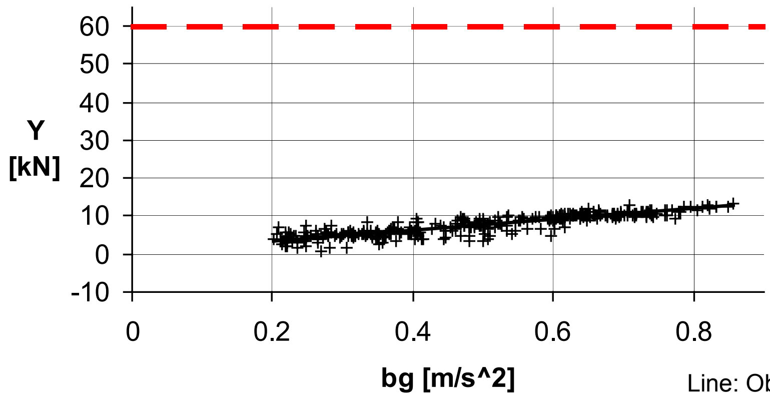
FEBA 1





FEBA 2





Line: Oberwinterthur-Stammheim
configuration: basic, LN 276A
right curves shown as left curves
dry rails

Test Vehicle for FEBA Running Gears
- Measured dynamic lateral wheel/rail-forces -

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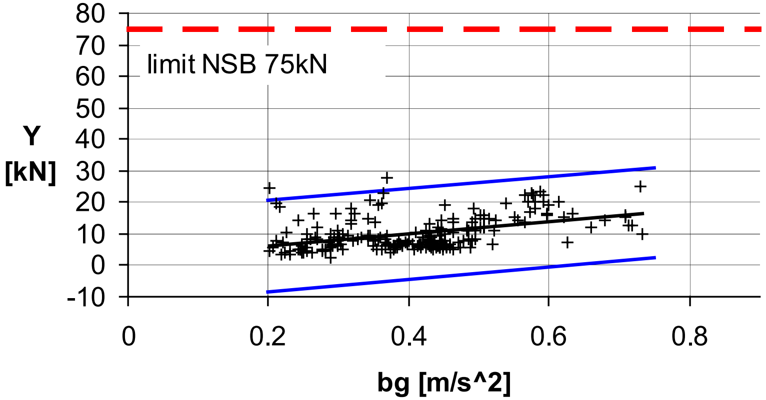
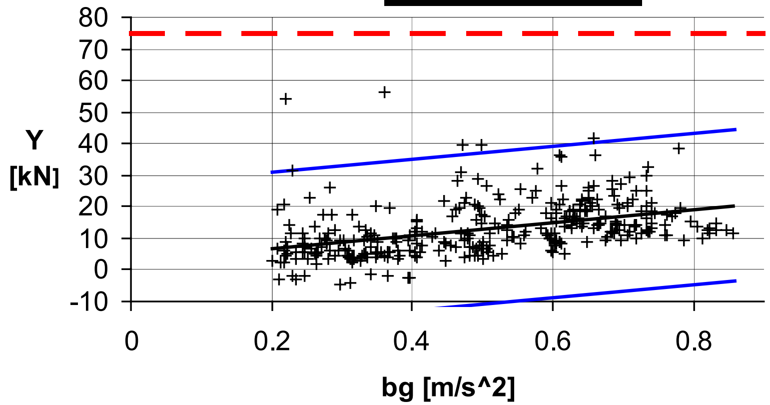
left wheels

axle load 13t

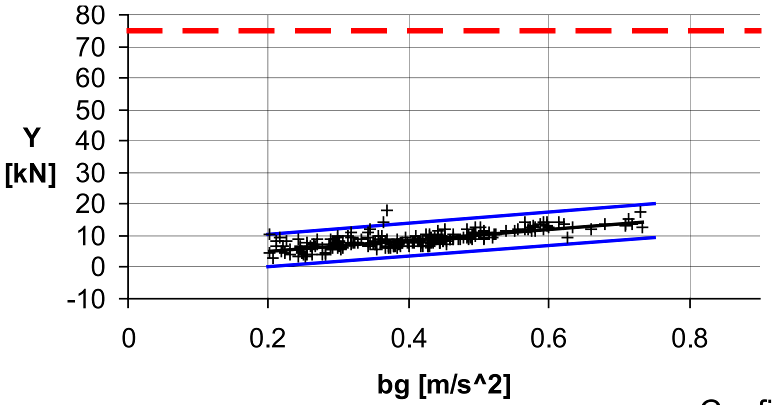
right wheels

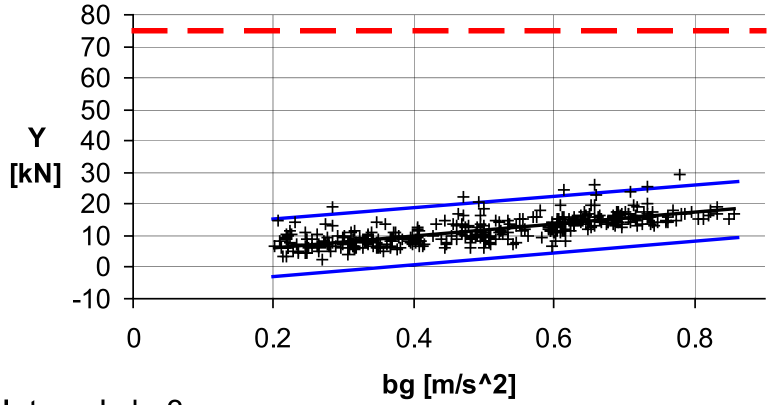
FEBA 1





FEBA 2





Confidence Intervals k=3
Left curves 99.85%-values,
right curves 0.15%-values

Line: Oberwinterthur-Stammheim
configuration: basic, LN 276A
right curves shown as left curves
dry rails

Test Vehicle for FEBA Running Gears
- Measured derailment quotient Y/Q -

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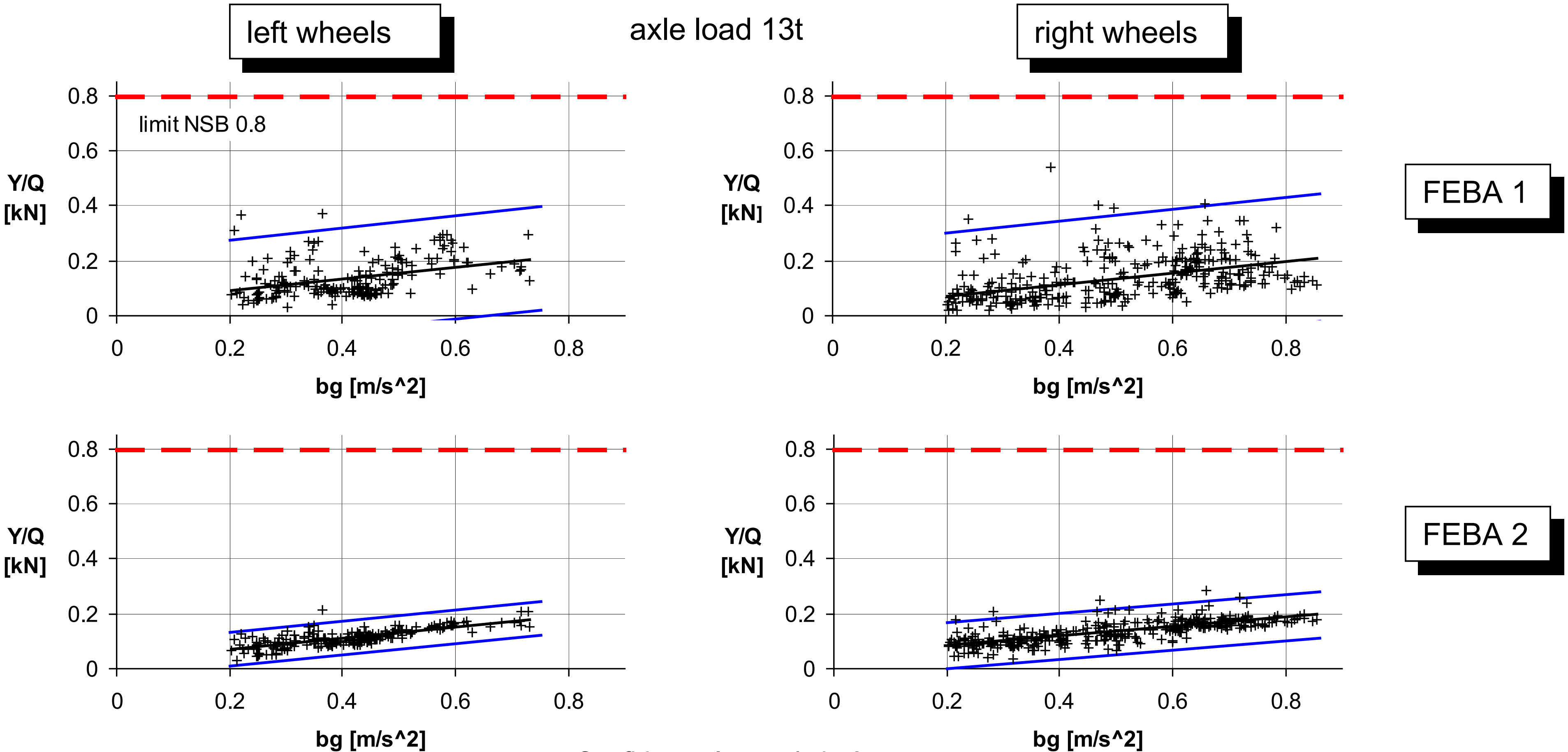

Confidence Intervals k=3
Left curves 99.85%-values,
right curves 0.15%-values

Line: Oberwinterthur-Stammheim
configuration: basic, LN 276A
right curves shown as left curves
dry rails
values averaged over 2m

Test Vehicle for FEBA Running Gears
- Measured sum of lateral wheel/rail-forces ΣY-

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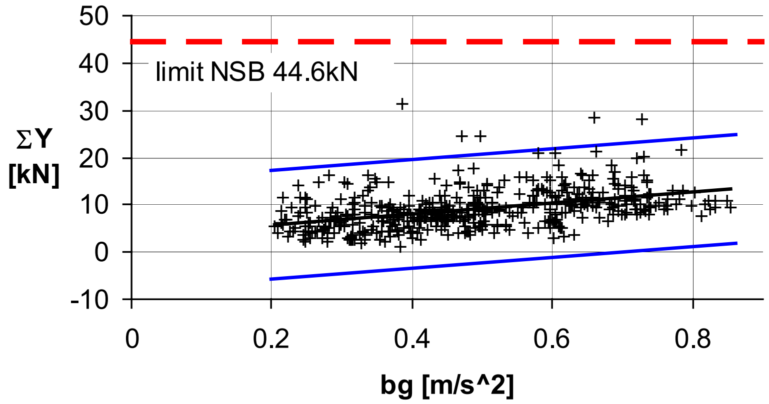
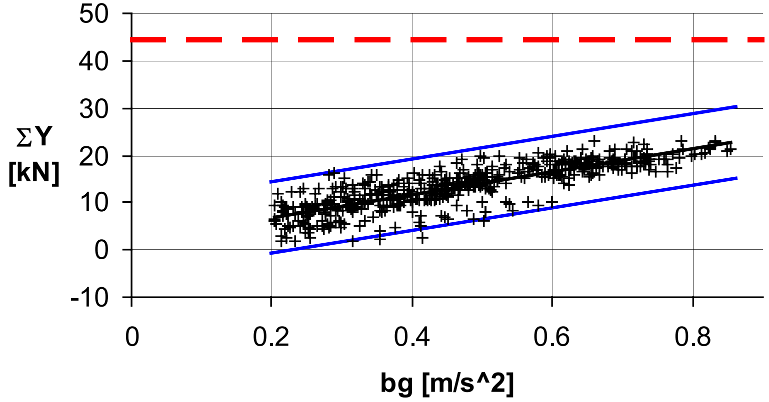
axle load 13t



FEBA 1



FEBA 2

Confidence Intervals k=3
Left curves 99.85%-values,
right curves 0.15%-values

Line: Oberwinterthur-Stammheim
configuration: basic, LN 276A
right curves shown as left curves
dry rails
values averaged over 2m

Test Vehicle for FEBA Running Gears
- Measured dynamic lateral wheel/rail-forces -

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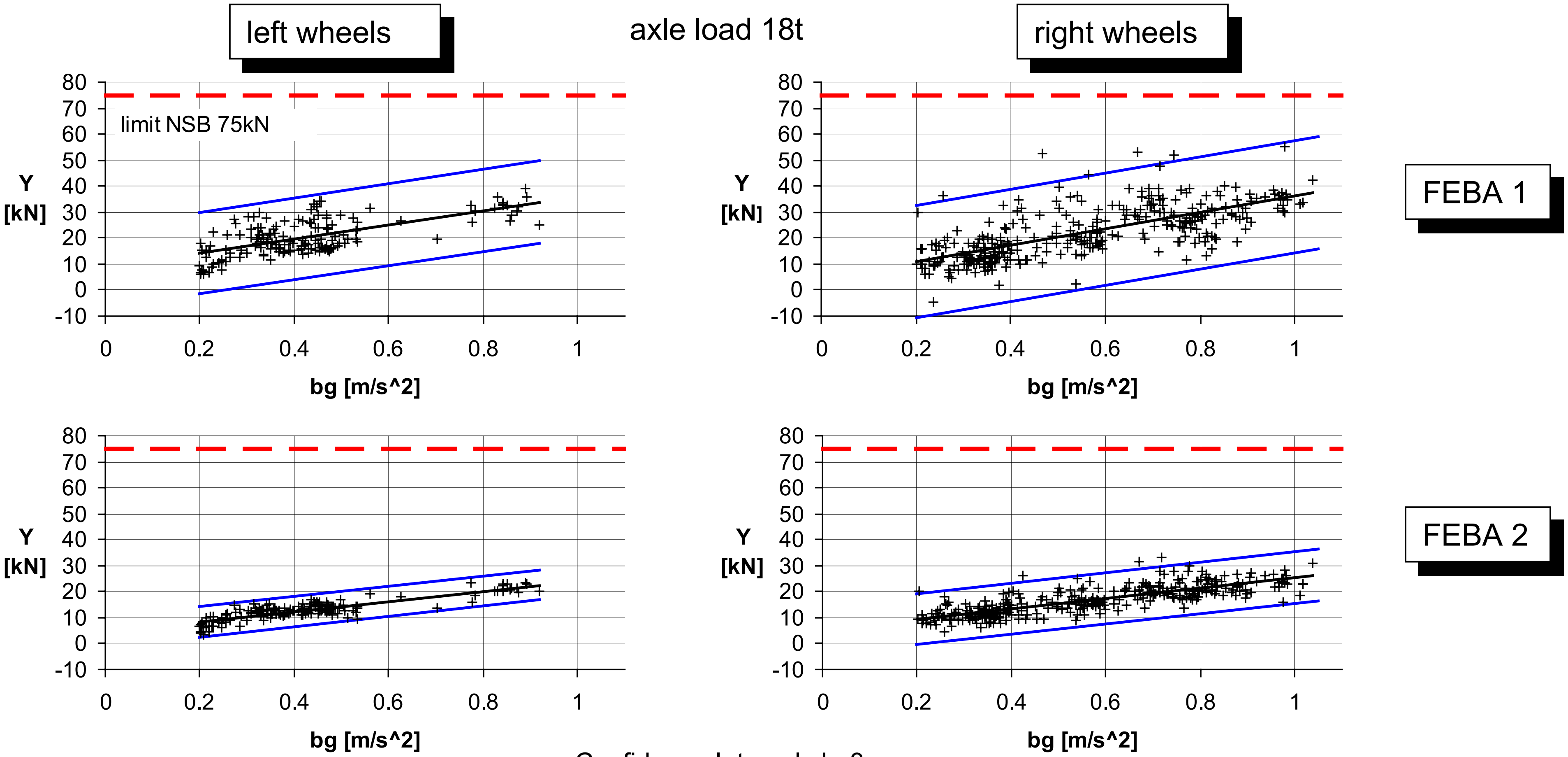

Confidence Intervals k=3
Left curves 99.85%-values,
right curves 0.15%-values

Line: Oberwinterthur-Stammheim
configuration: basic, LN 342A2
right curves shown as left curves
wet rails

Test Vehicle for FEBA Running Gears
- Measured derailment quotient Y/Q -

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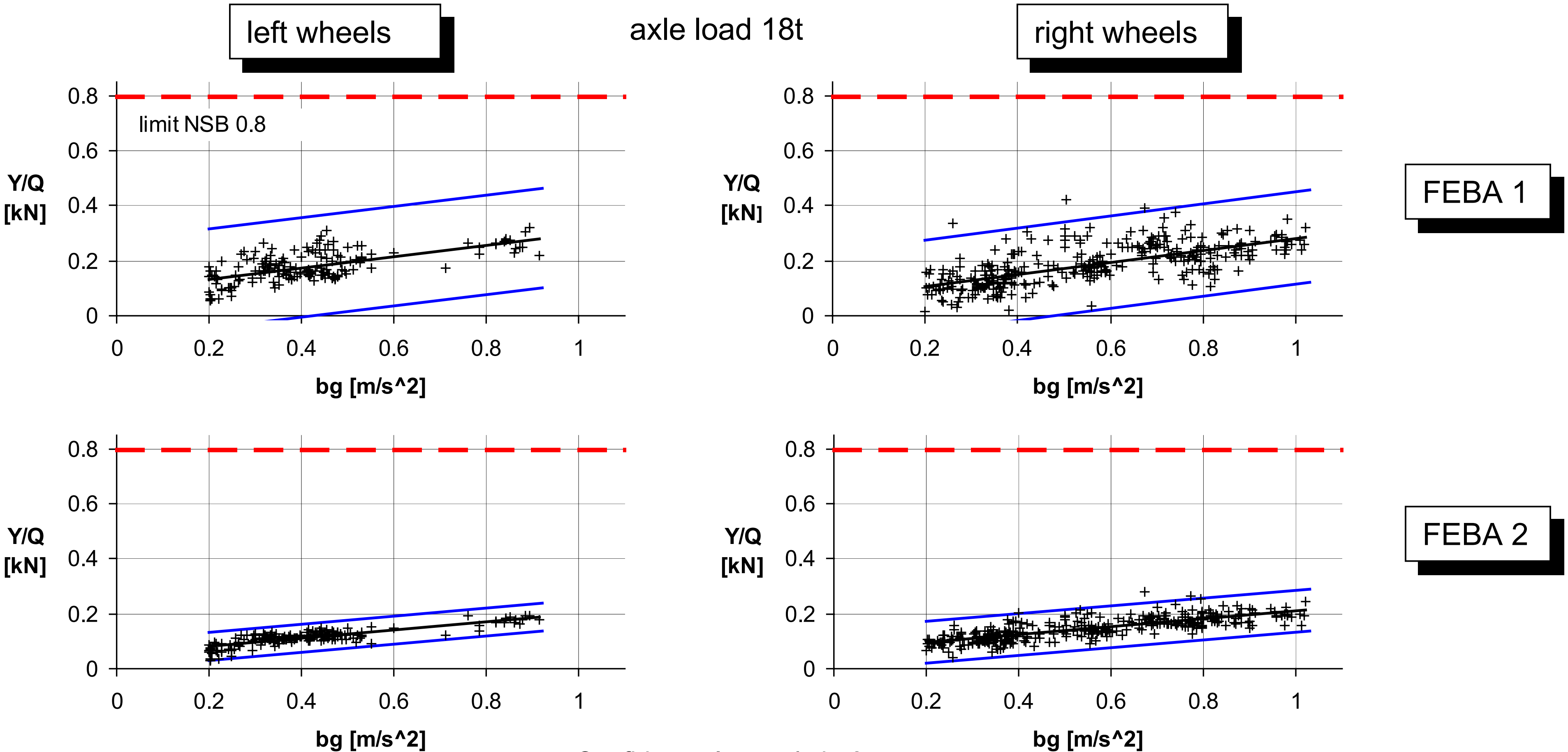


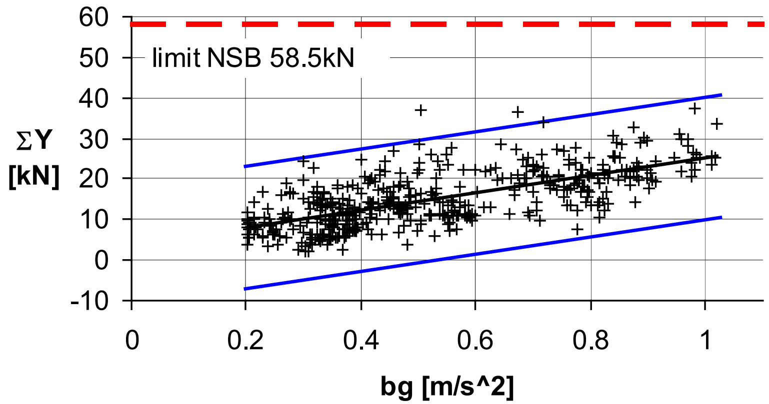
Confidence Intervals k=3
Left curves 99.85%-values,
right curves 0.15%-values

Line: Oberwinterthur-Stammheim
configuration: basic, LN 342A3
right curves shown as left curves
wet rails
values averaged over 2m

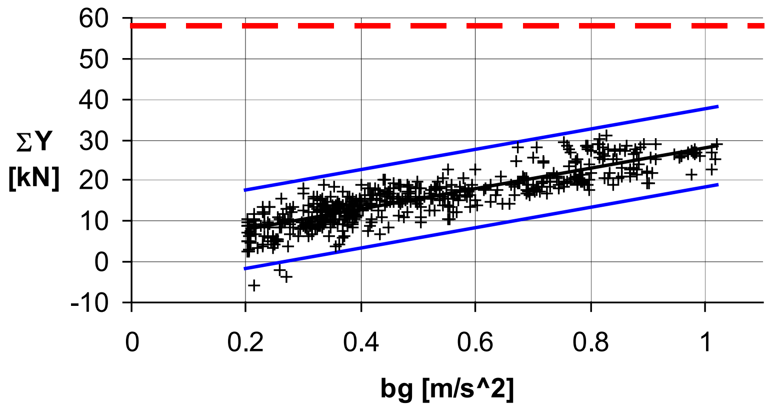
Test Vehicle for FEBA Running Gears
- Measured sum of lateral wheel/rail-forces ΣY-

ADtranz
DaimlerChrysler Rail Systems

axle load 18t



FEBA 1



FEBA 2

Confidence Intervals k=3
Left curves 99.85%-values,
right curves 0.15%-values

Line: Oberwinterthur-Stammheim
configuration: basic, LN 342A3
right curves shown as left curves
wet rails
values averaged over 2m

Conclusions

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Coupled single axle running gears FEBA

- were invented by Adtranz Winterthur
- replace conventional Jakob's bogies in articulated trains
- allow an easy separation for maintenance without subsidiary devices
- has been tested with speed of up to 180 km/h without any problems
- are built with proven elements
- offer a good ride comfort and stability behaviour
- showed an excellent curving behaviour with good radial steering and low forces between wheel and rail