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

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DaimlerChrysler Rail Systems (Switzerland) Ltd, Winterthur
Contents

- 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

- 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

- **Bogie**
  - Conventional: +
  - Weight: -

- **Jakob Bogie**
  - Conventional: -
  - Weight: +

- **Coupled single-axles FEBA**
  - New: +
  - Weight: +
Decoupling of coupled single axles FEBA

- Decoupling is very easy
- Separated coaches can be moved without subsidiary device
EMU NSB Class 72
Technical Data

- 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

Coupled single axle running gears FEBA
FEBA Single Axle Running Gears

Principle

Flexible Einzelachs BAukasten
(Flexible Modular Single Axle Running Gear)
FEBA Single Axle Running Gears
Comparison with Conventional Concepts

Single Axle Gear

Coupled FEBA Gears

Jakob Bogie
Test Vehicle for FEBA Running Gears
Running Gear Prototype
Test Vehicle for FEBA Running Gears
Design of Test Vehicle

Unsere Neue Fahrwerktechnologie...
...im Test für Sie

14 248
2 600
38 496
14 248
FEBA Single Axle Running Gears
Models for Vehicle Dynamics Simulations

- Test vehicle

- NSB Class 72
FEBA Single Axle Running Gears
Curving Simulation

- Angle of attack
- Lateral wheel-rail force

**Angle of attack**

- Soft coupling of the running gears
- Hard coupling of the running gears

**Lateral wheel-rail force**

- $aq = 1 \text{ m/s}^2$
- $aq = 0 \text{ m/s}^2$

Curve radius [m] vs. $\alpha$ [mrad]

Curve radius [m] vs. $Y$ [kN]
Tests of Single Axle Running Gears FEBA

Test Purposes

- 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

- 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

- 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 -

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

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 -

Line: Gümligen-Thun
configuration: basic
Test Vehicle for FEBA Running Gears
- steering angle on dry rails -

- Line: Oberwinterthur-Stammheim
- Speed: 70-110 km/h
- Rails: Dry
- Configuration: Basic
Test Vehicle for FEBA Running Gears
- steering angle on wet rails -

Line: Oberwinterthur-Stammheim
Speed: 70-110km/h
Rails: wet
Configuration: basic
Test Vehicle for FEBA Running Gears
Steering angle: dependency on weather conditions

Steering angle related to ideal steering angle

<table>
<thead>
<tr>
<th>Condition</th>
<th>Dry Rails</th>
<th>Wet Rails</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ideal</td>
<td>100</td>
<td>73.7</td>
</tr>
<tr>
<td>Coupled FEBAs</td>
<td>83.8</td>
<td>73.7</td>
</tr>
<tr>
<td>Conventional bogie (rigid axle guidance)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

steering angle related to ideal steering angle

<table>
<thead>
<tr>
<th>Coupled FEBAs, stiffness of coupling</th>
<th>Conventional bogie (rigid axle guidance)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ideal</td>
<td>Ideal</td>
</tr>
<tr>
<td>Coupled FEBAs, stiffness of coupling</td>
<td>Conventional bogie (rigid axle guidance)</td>
</tr>
<tr>
<td>low</td>
<td>low = 25 kN/mm radial stiffness of the sphäro-links on the coupling-bars</td>
</tr>
<tr>
<td>medium</td>
<td>medium = 50 kN/mm</td>
</tr>
<tr>
<td>high</td>
<td>high = 70 kN/mm</td>
</tr>
</tbody>
</table>

dependency on coupling-stiffness
Test Vehicle for FEBA Running Gears
- Advantages of the good steering angle -

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 -

Axle Load 13t

Line: Oberwinterthur-Stammheim
dry rails
positive forces are acting towards curving center
Test Vehicle for FEBA Running Gears
- Measured quasistatic lateral wheel/rail-forces -

Axle Load 18t

Line: Oberwinterthur-Stammheim
wet rails
positive forces are acting towards curving center

Prudhomme (k=0.85) 58.6kN

limit NSB 60kN
Test Vehicle for FEBA Running Gears
Lateral forces: Comparison with calculation

- Prudhomme (k=0.85) 44.6kN
- limit NSB 60kN
- calculation
  bg=0.5m/s²
  dry rail
  creep-force coefficient 0.3

FEBA 1, axle load 13t
Test Vehicle for FEBA Running Gears
- Measured quasistatic lateral wheel/rail-forces -

Left wheels

Axle load 13t

Right wheels

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 -

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 -

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 $\Sigma Y$-

axle load 13t

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 -

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 -

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 $\Sigma Y$-

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

**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