BONATRANS
RESILIENT WHEELS

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Permanent growth of passenger and freight transport

Causes increase of excessive noise and vibration

Results in requirements for minimization of these negative consequences = one of the most important tasks of transport vehicle manufacturers
BONATRANS RESILIENT WHEELS

Wheel-to-rail contact, particularly in track curves and track loops

↓

Major source of noise emissions in cities

↓

Development of resilient wheel Bonatrans
BONATRANS WHEEL CHARACTERISTICS

MAJOR TASKS SOLVED BY RESILIENT WHEELS DESIGN:

- Noise absorption – low noise
- Low weight
- Kick bounce movement reduction
- Damping of high-pitched whine and rolling noise (Reduced vibration)
- Easy to fit and disassembly
- Decreased wear of wheel tread and rail
- Minimizing of wheel flange wear
- Simple assembly and disassembly equipment
- Bigger available area of wheel web for other accessories (brake discs, gears, couplings)
BASIC TECHNICAL DATA (STANDARD)

- Wheel diameter: 510 – 910 mm (20“ – 36“)
- Weight: 130 – 397 kg (287 – 875 lbs)
- Static vertical load: 40 – 85 kN (8992 – 19109 lbf)
- Maximal lateral load: 20 – 45 kN (4496 – 10116 lbf)
- Maximal operating speed: up to 90 km/h (56 mph)

On demand loading data beyond the above ranges can be applied (see reference designs later)
DAMPING CHARACTERISTICS

(Comparison between older resilient wheel design and Bonatrans design for tramcar T3)

Characteristics for rubber-sprung wheels
straight track, speed: 40 km/h

![Graph: LpAeq,T vs Frequency for straight track, 40 km/h]

- Previous design: LpAeq,T = 102.3 dB, LpA 1/3 (f = 200-8000 Hz) = 76.0 - 92.7 dB
- Bonatrans design: LpAeq,T = 96.5 dB, LpA 1/3 (f = 200-8000 Hz) = 74.6 - 89.6 dB
- Difference: 5.8 dB up to 6.4 dB per frequency

Characteristics for rubber-sprung wheels
curve, speed: 25 km/h

![Graph: LpAeq,T vs Frequency for curve, 25 km/h]

- Previous design: LpAeq,T = 102.9 dB, LpA 1/3 (f = 200-8000 Hz) = 73.5 - 100.6 dB
- Bonatrans design: LpAeq,T = 91 dB, LpA 1/3 (f = 200-8000 Hz) = 72.3 - 82.0 dB
- Difference: 11.9 dB up to 22 dB per frequency

40 km/h (24.7 mph)                                    25 km/h (15.5 mph)
RESILIENT WHEEL SERVICE PROVEN DESIGN

In Service Since 1997
Operating in 23 Transit Agencies World Wide
Over 250 Million Cumulative Miles
REFERENCES

Bonatrans resilient wheels have been delivered to:

A. City Transportation Authorities all over Europe

- Czech republic: Prague, Brno, Ostrava, Pilsen, Liberec, Most, Olomouc
- Slovak Republic: Bratislava, Kosice
- Italy: Torino, Messina
- Spain: Alicante
- Poland: Cracow, Gdansk
- Hungary: Budapest
- Bosnia and Herzegovina: Sarajevo
- Latvia: Riga
- Russia: St. Petersburg
- Ukraine: Doneck, Odessa, Nikolaev
- Norway: Metro Oslo
- Bulgaria: Sofia
- Turkey: Istanbul
REFERENCES

Bonatrans resilient wheels have been delivered to:

B. Tram and Metro Car Manufacturers:

- Alstom, Savigliano, Italy
- Alstom (now Vossloh), Valencia, Spain
- Siemens, Prague, Cz.Rep.
- Siemens, Austria
- Hyundai Rotem, Korea
- Skoda Transporation, Pilsen, Czech Republic
- Inekon Trams, Czech Republic
- PTMZ, St. Petersburg, Russia
- Tatra Yug, Ukraine
- H. Cegielski, Poland
REFERENCES

Kilometres in operation of Bonatrans resilient wheels that are longest in operation in various municipal transit authorities by the end of 2003

<table>
<thead>
<tr>
<th>City</th>
<th>First delivery</th>
<th>Tram type</th>
<th>Total operation by 12/2003</th>
<th>First reprofilation</th>
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<tbody>
<tr>
<td>Ostrava</td>
<td>1997</td>
<td>T3</td>
<td>500 000 km</td>
<td>224 000 km</td>
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<tr>
<td>Brno</td>
<td>1998</td>
<td>KT8</td>
<td>300 000 km</td>
<td>220 000 km</td>
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<tr>
<td>Olomouc</td>
<td>1998</td>
<td>T3</td>
<td>200 000 km</td>
<td>100 000 km</td>
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<tr>
<td>Pilsen</td>
<td>1998</td>
<td>T3</td>
<td>250 000 km</td>
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<tr>
<td>Most</td>
<td>1998</td>
<td>ASTRA</td>
<td>240 000 km</td>
<td>Not reprofilated yet</td>
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<tr>
<td>Bratislava</td>
<td>1998</td>
<td>K2</td>
<td>200 000 km</td>
<td></td>
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</table>
WHEEL DESIGN

BASIC CONCEPT OF BONATRANS RESILIENT WHEEL
MAIN PARTS OF THE WHEEL

- Rubber segments
- Clamping ring
- Tire
- Locking ring
- Wheel centre
BONATRANS RESILIENT WHEEL DESIGN

FEM analyses are used to prove wheel strength properties.

Vibration wheel properties are verified with modal analyses.
WHEEL TESTING

Bonatrans resilient wheels underwent following operational and laboratory tests:

- Verifying of Life Cycle Costs (tyres and rubber segments)
- Vertical (up to 70 kN /15737 lbf/) and lateral (up to 40 kN /8992 lbf/) wheel strength
- Resistance against tyre/centre slipping (7 000 /61955 lb.in/ - 13 000 Nm /115060 lb.in/)
- Rubber segments fatigue properties (2,95x10^8 cycles, which corresponds with 400 000 km /248550 miles/)
- Noise reduction (inside and outside of the tramcar)
WHEEL TESTING
TEST RESULTS

Mechanical properties:
- Wheel centre, tyre as well as rubber segments met requirements

Tyre life span:
- 2 to 2.5 times longer in comparison with original Tatra design
- Slightly longer in comparison with West-European design

Noise reduction:
- Up to 6.4 dB in straight lines and up to 22 dB in curves in comparison with original Tatra design
- 0.1-6.2 in curves and 0.2-2.2 in straight lines in comparison with West-European design
Design Examples
Wheel for Cityway trams (Alstom)

100% low-floor tram, wheels mounted either on semi-axle or on a drive

- Diameter: 680 mm (26.8“)
- Max. radial load: 50 kN (11240 lbf)
- Max. axial load: 35 kN (7868 lbf)
- Max. torque: 6800 Nm (60185 lb.in)
- Weight: 161 kg (355 lb)
Design Examples
Wheel for Skoda Transportation - ASTRA trams (Škoda Pilsen)

60% low-floor tram, wheels mounted on axle

- Diameter: 610 mm (24“)
- Max. radial load: 50 kN (11240 lbf)
- Max. axial load: 35 kN (7868 lbf)
- Max. torque: 4700 Nm (41599 lb.in)
- Weight: 158.5 kg (349.4 lb)
Design Examples
Wheel for Eurotram (Bombardier)

100% low-floor tram, wheels mounted on a drive

- Diameter: 550 mm (21.6“)
- Max. radial load: 54 kN (12140 lbf)
- Max. axial load: 36 kN (8093 lbf)
- Max. torque: 2600 Nm (23012 lb.in)
- Weight: 125 kg (276 lb)

Note: This design was quoted and tested but not supplied yet.
Design Examples
Wheel for Metro and Sub-urban Transport (Skoda Transportation)

Diameter
- Max. radial load 70 kN (15737 lbf)
- Max. axial load 50 kN (11240 lbf)
- Max. torque 12000 Nm (106209 lb.in)
- Weight 423 kg (incl. discs) 46 kg (101 lbf)

Both wheel and brake disc are Bonatrans design
Design Examples

Wheels for Alicante Train/Tram (Vossloh)

- Diameter: 720 mm (28.3“)
- Max. radial load: 60 kN (13487 lbf)
- Max. axial load: 40 kN (8992 lbf)
- Max. torque: 34,000 Nm (25077 lb.foot)
- Weight: 247 kg (544 lb)
Wheel and damper are Bonatrans design.

- **Diameter**: 850 mm (33.5“)
- **Max. radial load**: 70 kN (15736 lbf)
- **Max. axial load**: 50 kN (11240 lbf)
- **Max. torque**: 36,000 Nm (26552 lb.foot)
- **Weight**: 377 kg (incl. damper) (831 lb)
- **Weight of damper**: 7 kg (15.4 lb)
Design Examples
Wheel for new Škoda Transportation Tram 15T (for Prague)

- Diameter: 660 mm (26“)
- Max. radial load: 50 kN (11240 lbf)
- Max. axial load: 35 kN (7686 lbf)
- Max. torque: 4700 Nm (41598 lb.in)
- Weight: 233 kg (514 lb)

The tram is 100% low-floor. Emergency braking by tyre faces.
## References

<table>
<thead>
<tr>
<th>Project</th>
<th>Type</th>
<th>Bonatrans design</th>
<th>Car Builder</th>
<th>End user / Country</th>
<th>Scope of Supply</th>
<th>Year(s)</th>
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<tbody>
<tr>
<td>Cityway</td>
<td>Tram</td>
<td>Yes</td>
<td>Alstom</td>
<td>City authorities in Turin, Messina / Italy</td>
<td>Resilient Wheels</td>
<td>2000-2003</td>
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<td>T3, K2, T6A5, KT8D5</td>
<td>Tram</td>
<td>Yes</td>
<td>CKD</td>
<td>City authorities / Czech &amp; Slovak Rep., Hungary, Poland, etc.</td>
<td>Resilient Wheels</td>
<td>1998+</td>
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<td>ASTRA (03T)</td>
<td>Tram</td>
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<td>Skoda Transportation</td>
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<td>Resilient Wheels</td>
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<td>Trio</td>
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<td>Inekon Trams</td>
<td>City authorities / Czech &amp; Slovak Rep., Bulgaria</td>
<td>Resilient Wheels</td>
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<td>SF1000 Metro Oslo</td>
<td>Metro</td>
<td>Yes</td>
<td>Siemens</td>
<td>Oslo Sporvereien / Norway</td>
<td>Power wheelsets with resilient wheels and noise absorbers</td>
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<th>Scope of Supply</th>
<th>Year(s)</th>
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<tr>
<td>Low Floor Tram LVS2005</td>
<td>Tram</td>
<td>Yes</td>
<td>PTMZ St.Petersburg</td>
<td>St.Petersburg /Russia</td>
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<td>K-1</td>
<td>Tram</td>
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<td>Tatra Yug</td>
<td>Doneck, Odessa (Ukraine)</td>
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<td>Otogar LRV</td>
<td>LRV</td>
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<td>Hyundai Rotem/Korea</td>
<td>Istanbul / Turkey</td>
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<td>15T Prague</td>
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<td>Gimhae LRT</td>
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<td>Busan Gimhae Light Rail / Korea</td>
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<td>2008+</td>
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BONATRANS RUBBER RESILIENT WHEEL

EXCELLENT TECHNICAL CHARACTERISTICS

+ 

LONG LIFE-SPAN

+ 

REASONABLE PRICE

= 

LOW LIFE CYCLE COSTS
BONATRANS RUBBER RESILIENT WHEEL

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