BONATRANS
RESILIENT WHEELS

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BONATRANS

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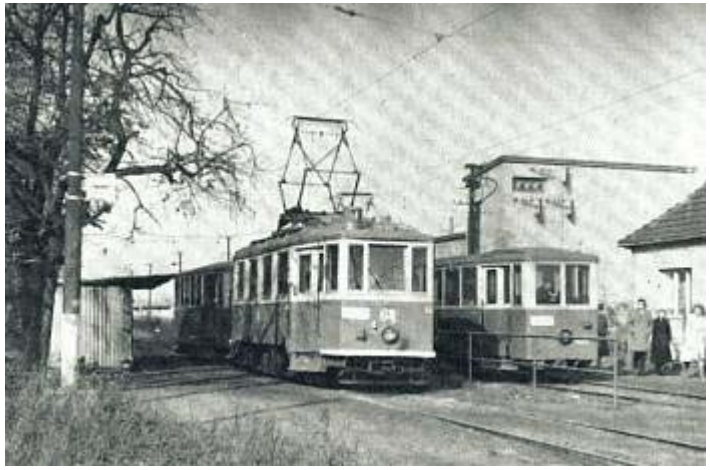


Permanent growth of passenger and freight transport

⇓

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)

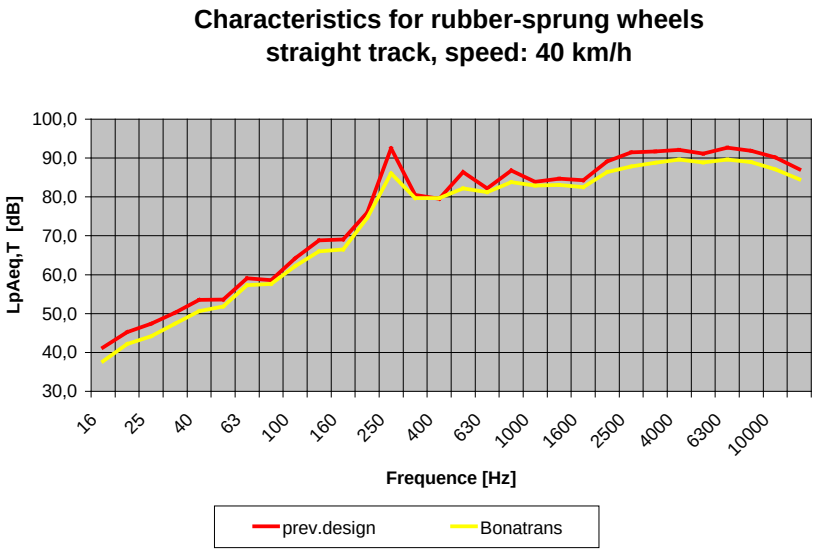
BASIC TECHNICAL DATA (STANDARD)

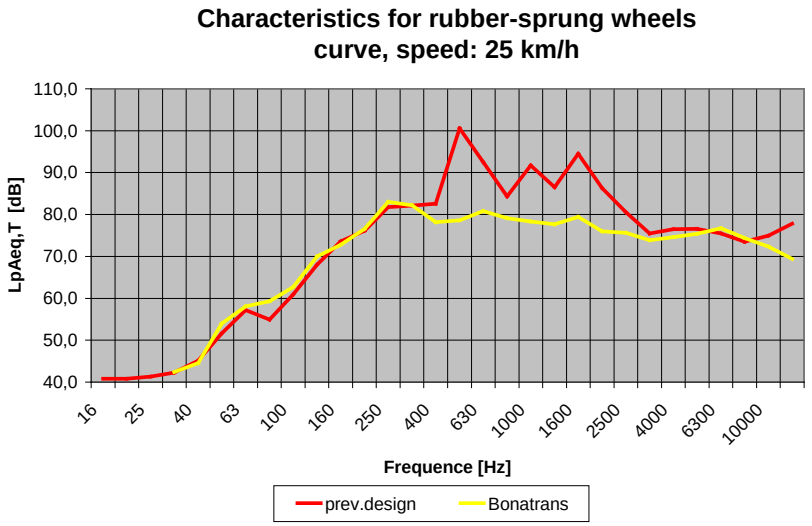
- **Wheel diameter:** 510 – 910 mm (20“ – 36“)
- **Weight:** 130 – 397 kg (287 – 875 lbs)
- **Static vertical load:** 40 – 85 kN (8992 – 19109 lbf)
- **Maximal lateral load:** 20 – 45 kN (4496 – 10116 lbf)
- **Maximal operating speed:** up to 90 km/h (56 mph)

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)





40 km/h (24.7 mph) 25 km/h (15.5 mph)

	Straight track, v = 40 km/h		Curve r = 30m, v = 25 km/h	
	$L_{pAeq,T}$	$L_{pA\ 1/3}$ (f = 200-8000 Hz)	$L_{pAeq,T}$	$L_{pA\ 1/3}$ (f = 200-8000 Hz)
Previous design	102,3 dB	76,0 - 92,7 dB	102,9 dB	73,5 - 100,6 dB
Bonatrans design	96,5 dB	74,6 - 89,6 dB	91 dB	72,3 - 82,0 dB
Difference	**5,8 dB**	**up to 6,4 dB per frequency**	**11,9 dB**	**up to 22 dB per frequency**

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
- Tyrkey Istanbul

REFERENCES

Bonatrans resilient wheels have been delivered to :

B. Tram and Metro Car Manufacturers :

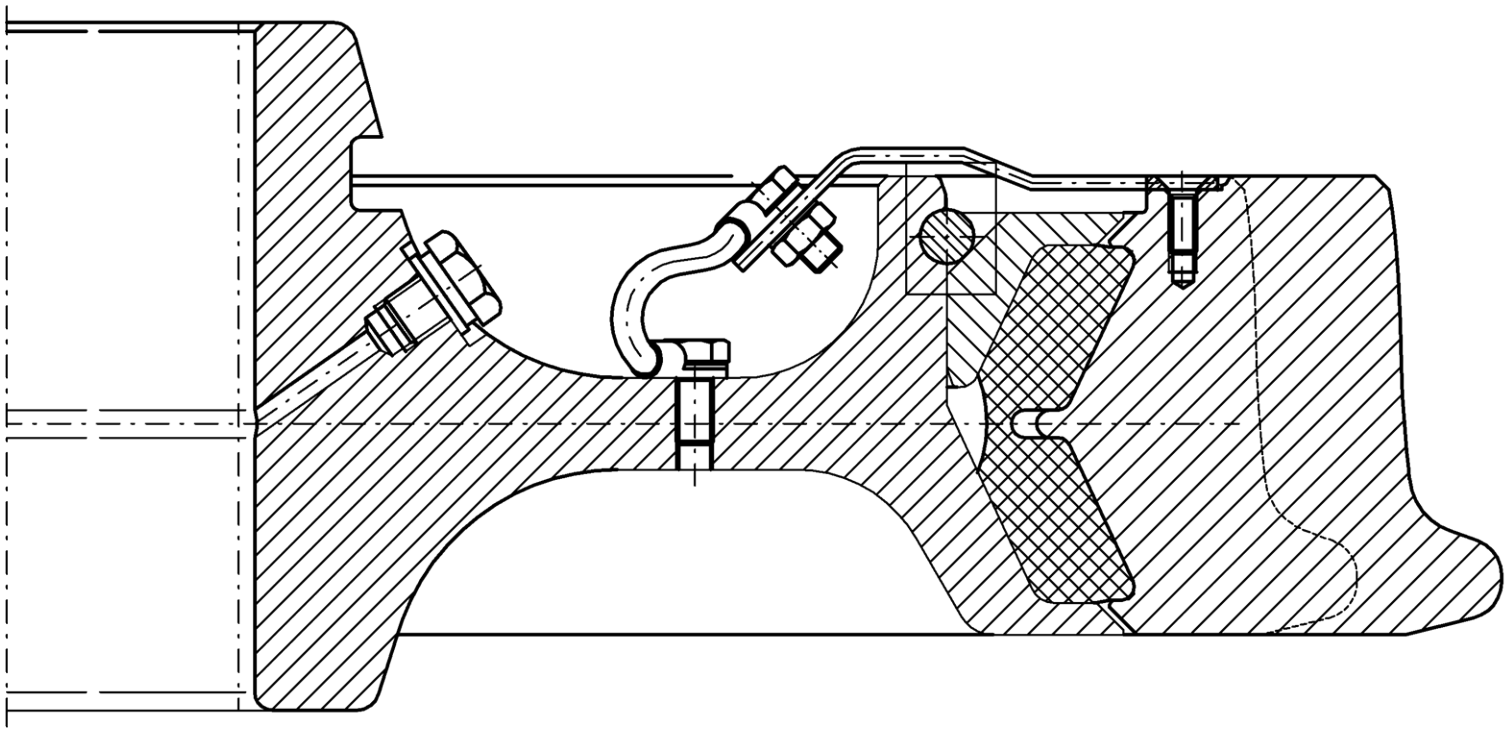
- **Alstom,** Savigliano**,** Italy
- **Alstom (now Vossloh),** Valencia, Spain
- **Siemens,** Prague, Cz.Rep.
- **Siemens,** Austria
- **Hyundai Rotem**, Korea
- **Skoda Transporation,** Pilsen, Czech Republic
- **Inekon Trams,** Czech Republic
- **PTMZ,** St. Petersburg, Russia
- **Tatra Yug,** Ukraine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

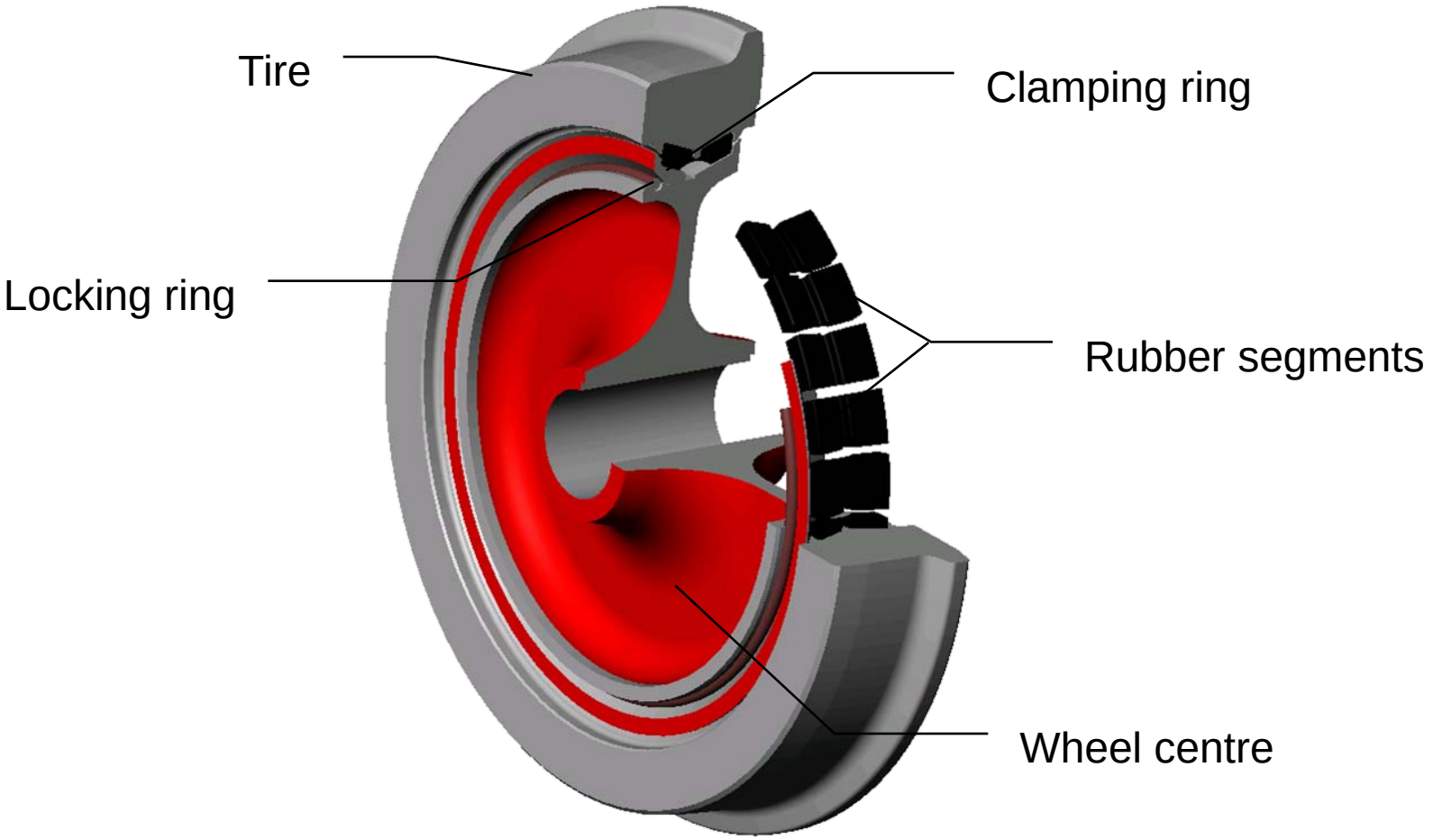
City	*First delivery*	*Tram type*	*Total operation by 12/2003*	*First reprofilation*
Ostrava	1997	T3	500 000 km	224 000 km
Brno	1998	KT8	300 000 km	220 000 km
Olomouc	1998	T3	200 000 km	100 000 km
Pilsen	1998	T3	250 000 km	Not reprofiled yet
Most	1998	ASTRA	240 000 km	
Bratislava	1998	K2	200 000 km	

WHEEL DESIGN



BASIC CONCEPT OF BONATRANS RESILIENT WHEEL

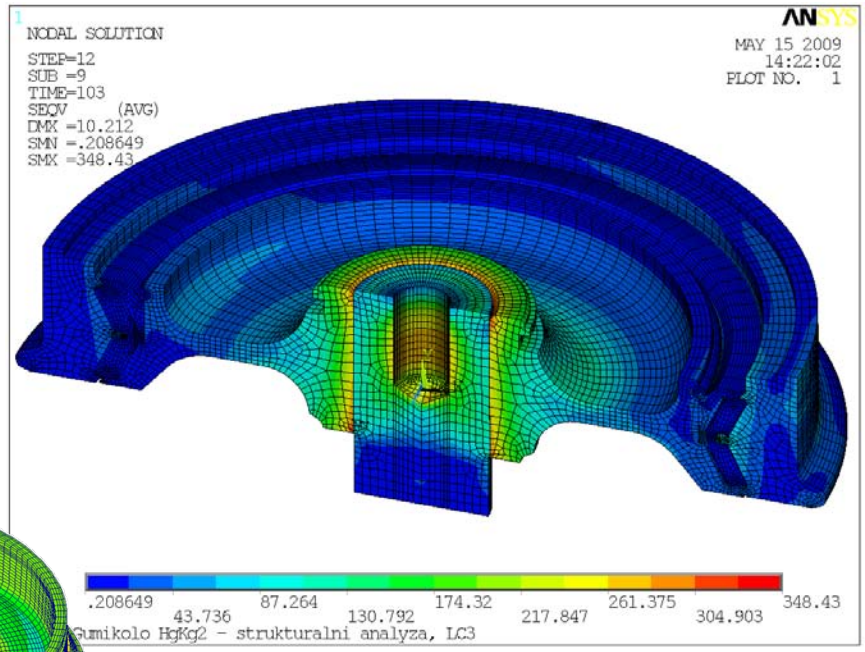
MAIN PARTS OF THE WHEEL

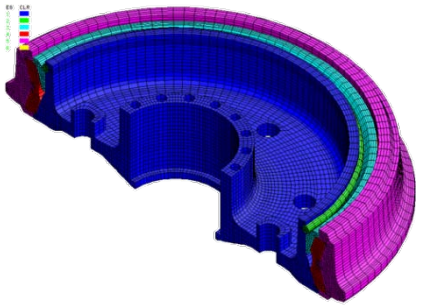


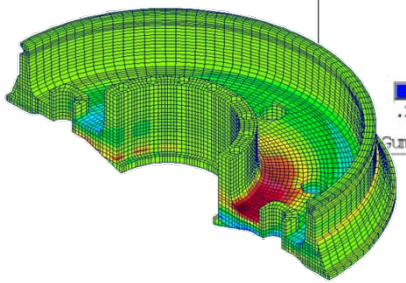
BONATRANS RESILIENT WHEEL DESIGN

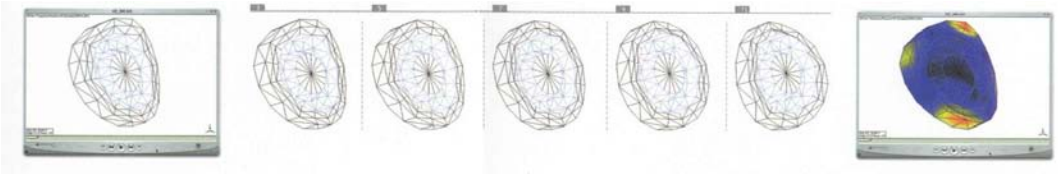
FEM analyses are used to prove wheel strength properties.

Vibration wheel properties are verified with modal analyses.







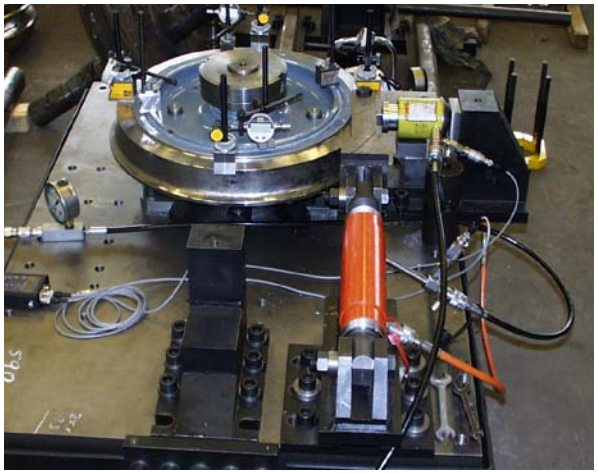


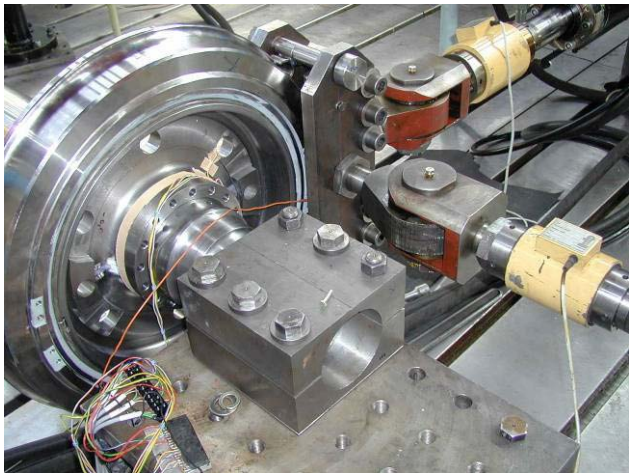
WHEEL TESTING

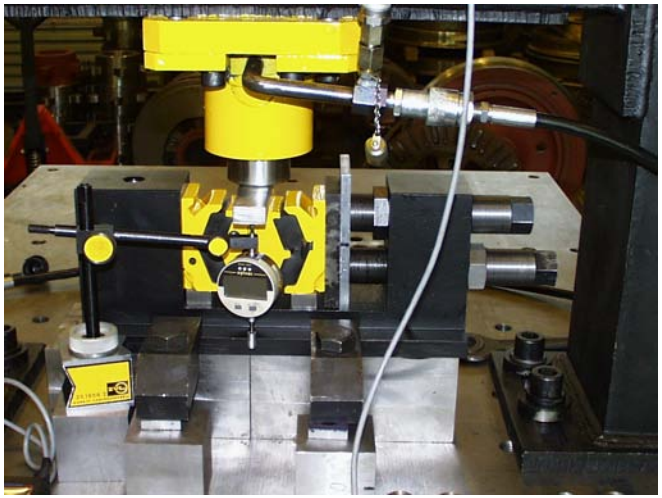
Bonatrans resilient wheels underwent following operational and laboratory tests :

- **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 ($2{,}95 \times 10^8$ 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 :

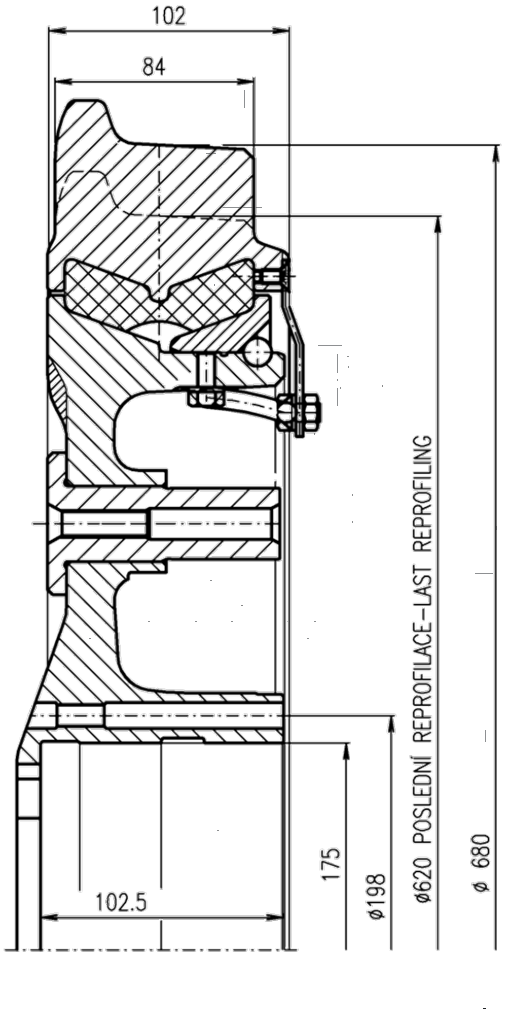
- 2 to 2.5times longer in comparison with original Tatra design
- Slightly longer in comparison with West-European design

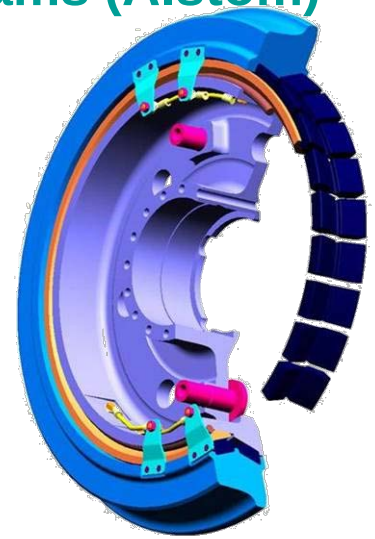
Noise reduction :

- Up to 6.4 dB in straight lines and up to 22dB 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)



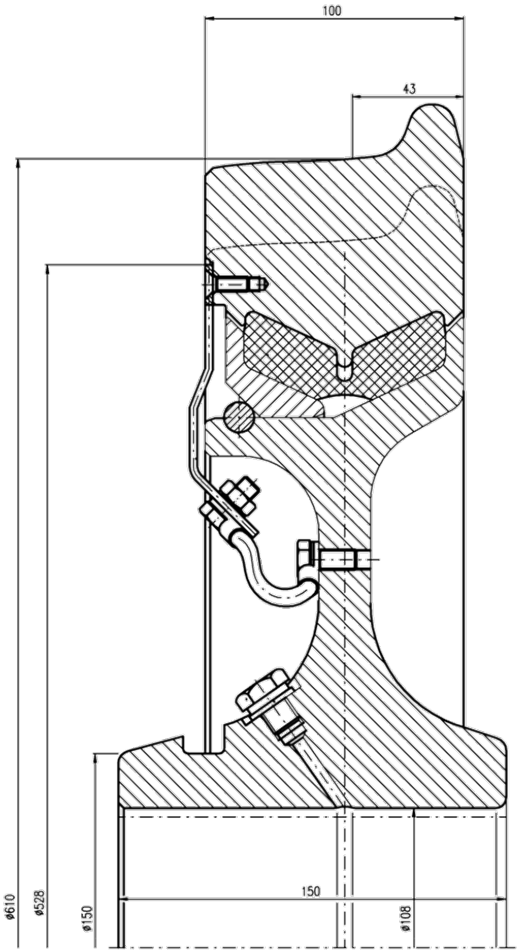


100% low-floor tram, wheels mounted either on semi-axle or on a drive

➢ 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)

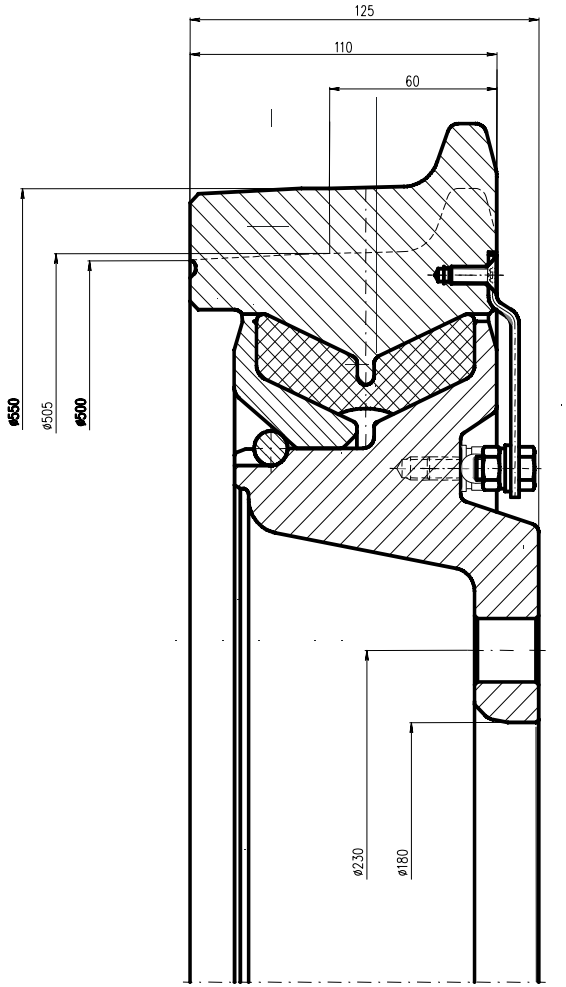


60% low-floor tram, wheels mounted on axle

➢ 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)



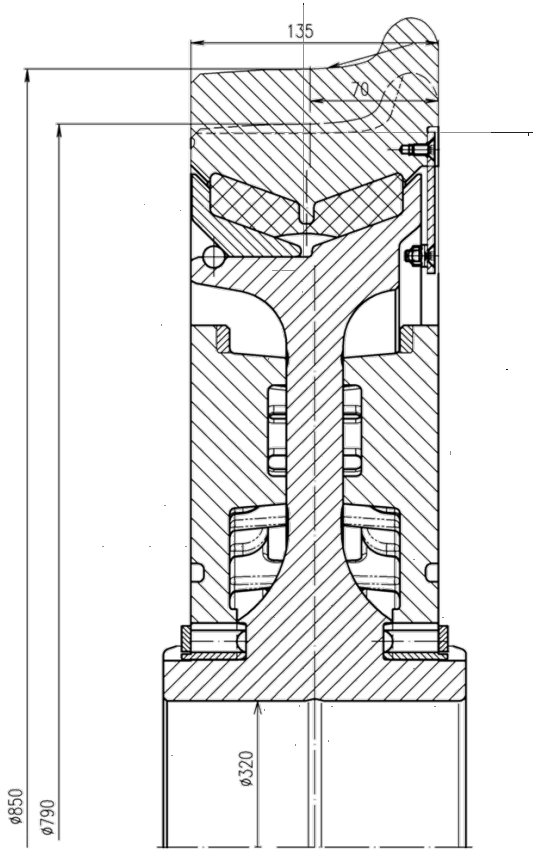
100% low-floor tram, wheels mounted on a drive

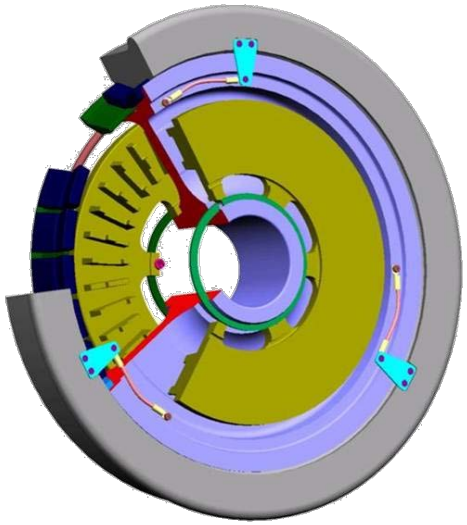
➢ Diameter	550 mm (21.6“)
➢ Max. radial load	54 kN (12140 lbf)
➢ Max. axial load	36 kN (8093 lbf)
➢ Max. torque	2600 Nm (23012 lb.in)
➢ Weight	125 kg (276 lb)

Note: This design was quoted and tested but not supplied yet.

Design Examples

Wheel for Metro and Sub-urban Transport (Skoda Transportation)



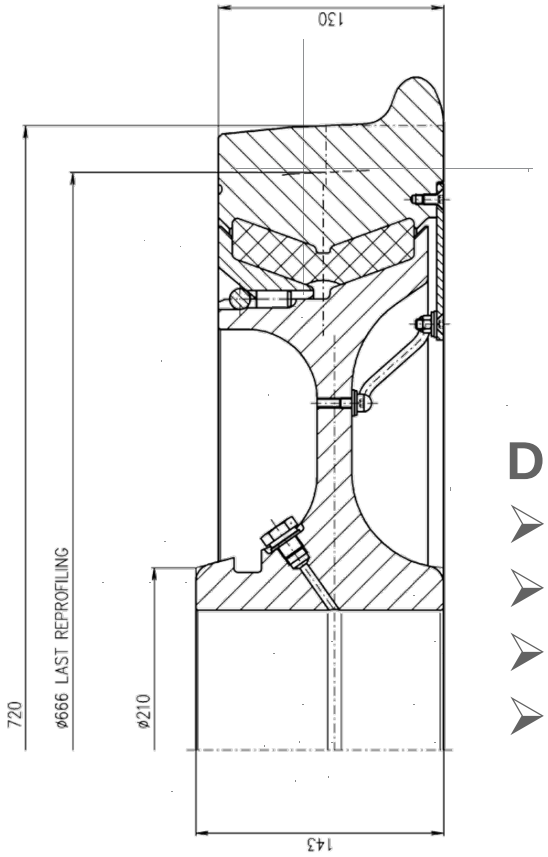


Diameter	**850 mm (33.5“)**
➢ **Max. radial load**	**70 kN (15737 lbf)**
➢ **Max. axial load**	**50 kN (11240 lbf)**
➢ **Max. torque**	**12000 Nm (106209 lb.in)**
➢ **Weight**	**423 kg (incl. discs) (933 lb)**
➢ **Weight of brake discs**	**46 kg (101 lbf)**

Both wheel and brake disc are Bonatrans design

Design Examples

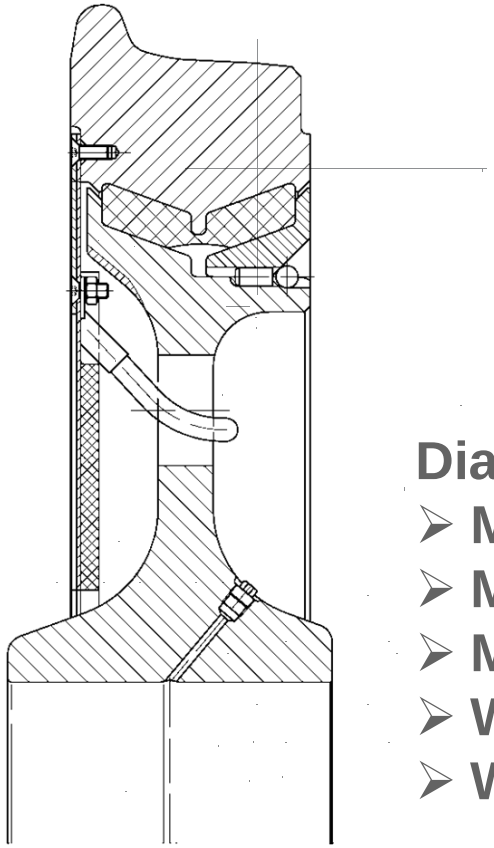
Wheels for Alicante Train/Tram (Vossloh)

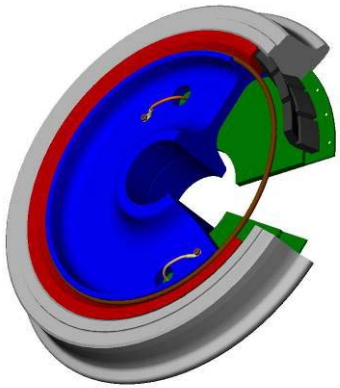


Diameter	**720 mm (28.3“)**
➢ Max. radial load	**60 kN (13487 lbf)**
➢ Max. axial load	**40 kN (8992 lbf)**
➢ Max. torque	**34,000 Nm (25077 lb.foot)**
➢ Weight	**247 kg (544 lb)**

Design Examples

Wheel for Metro Cars Oslo (Siemens)



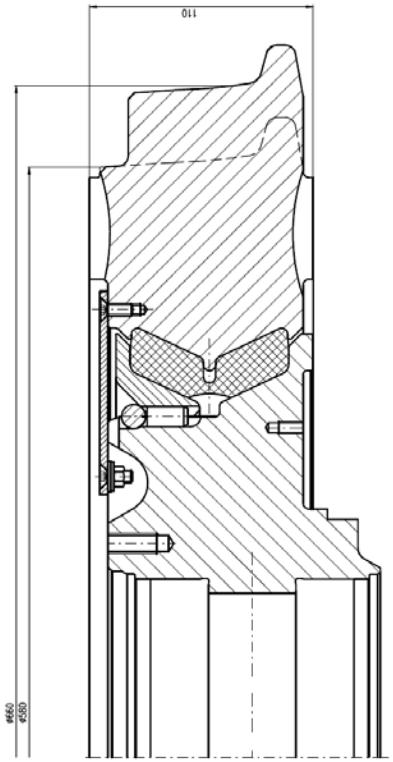


Diameter	**850 mm (33.5“)**
➢ **Max. radial load**	**70 kN (15736 lbf)**
➢ **Max. axial load**	**50 kN (11240 lbf)**
➢ **Max. torque**	**36,000 Nm (26552 lb.foot)**
➢ **Weight**	**377 kg (incl. damper) (831 lb)**
➢ **Weight of damper**	**7 kg (15.4 lb)**

Wheel and damper are Bonatrans design

Design Examples

Wheel for new Škoda Transportation Tram 15T (for Prague)



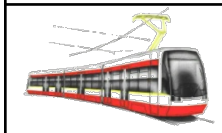
Diameter	**660 mm (26“)**
➢ **Max. radial load**	**50 kN (11240 lbf)**
➢ **Max. axial load**	**35 kN (7686 lbf)**
➢ **Max. torque**	**4700 Nm (41598 lb.in)**
➢ **Weight**	**233 kg (514 lb)**

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

References

	Project	Type	Bonatrans design	Car Builder	End user / Country	Scope of Supply	Year(s)
	**Cityway**	Tram	Yes	Alstom	City authorities in Turin, Messina / Italy	Resilient Wheels	2000-2003
	**T3, K2, T6A5, KT8D5**	Tram	Yes	CKD	City authorities / Czech & Slovak Rep., Hungary, Poland, etc.	Resilient Wheels	1998+
	**ASTRA (03T)**	Tram	Yes	Skoda Transportation	City authorities / Czech & Slovak Rep.,	Resilient Wheels	1999+
	**Trio**	Tram	Yes	Inekon Trams	City authorities / Czech & Slovak Rep., Bulgary	Resilient Wheels	2004+
	**Alicante Train/Tram**	Train/ Tram	Yes	Vossloh	FGV Alicante / Spain	Power and trailer wheelsets with Resilient Wheels	2005-2007
	**SF1000 Metro Oslo**	Metro	Yes	Siemens	Oslo Sporvereien / Norway	Power wheelsets with resilient wheels and noise absorbers	2006+

References

	Project	Type	Bonatrans design	Car Builder	End user / Country	Scope of Supply	Year(s)
	**Low Floor Tram LVS2005**	Tram	Yes	PTMZ St.Petersburg	St.Petersburg /Russia	Resilient wheels	2006+
	**K-1**	Tram	Yes	Tatra Yug	Doneck, Odessa (Ukraine	Resilient wheels	2006+
	**Otogar LRV**	LRV	Yes	Hyundai Rotem/Korea	Istanbul / Turkey	Resilient wheels	2007+
	**15T Prague**	Tram	Yes	Škoda Transportation	Prague /Czech Republic	Resilient wheels	2008+
	**Gimhae LRT**	LRV	Yes	Hyundai Rotem/Korea	Busan Gimhae Light Rail / Korea	Resilient wheels	2008+

BONATRANS RUBBER RESILIENT WHEEL

EXCELENT TECHNICAL CHARACTERISTICS

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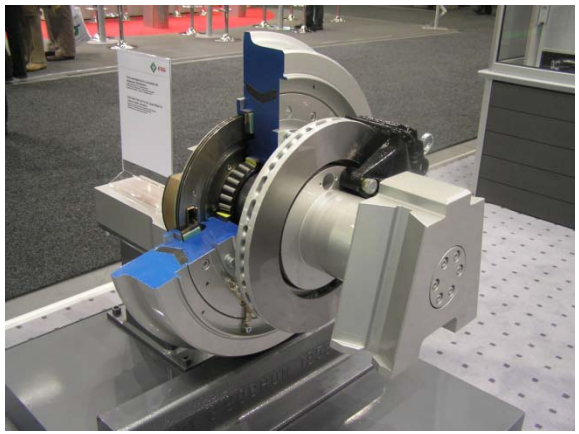
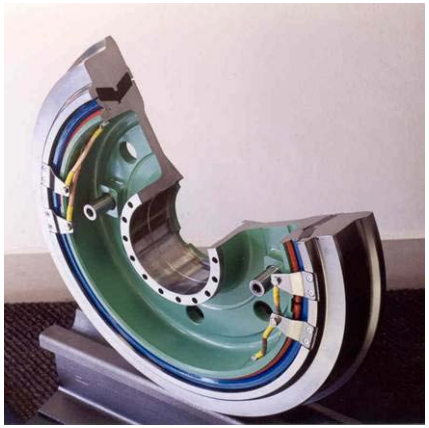
LONG LIFE-SPAN





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REASONABLE PRICE

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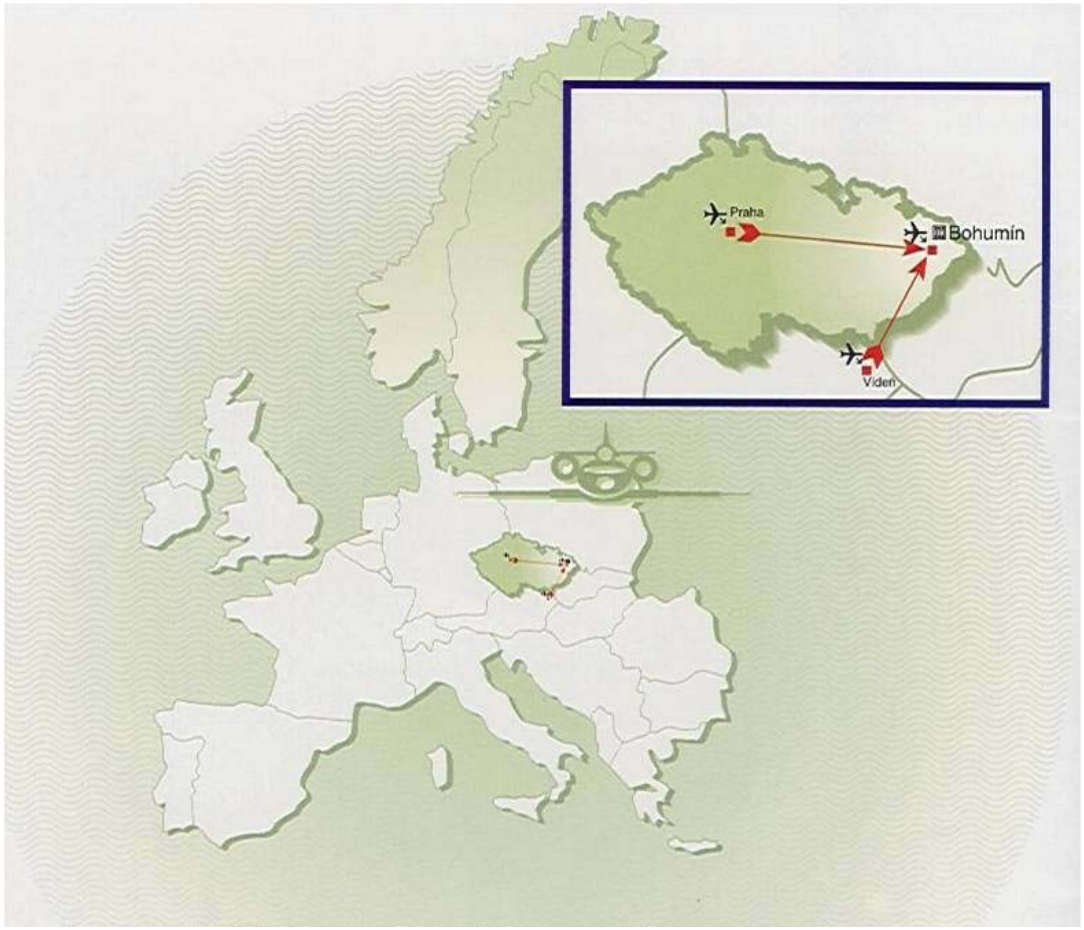
<u>LOW LIFE CYCLE COSTS</u>

BONATRANS RUBBER RESILIENT WHEEL



THANK YOU FOR YOUR ATTENTION

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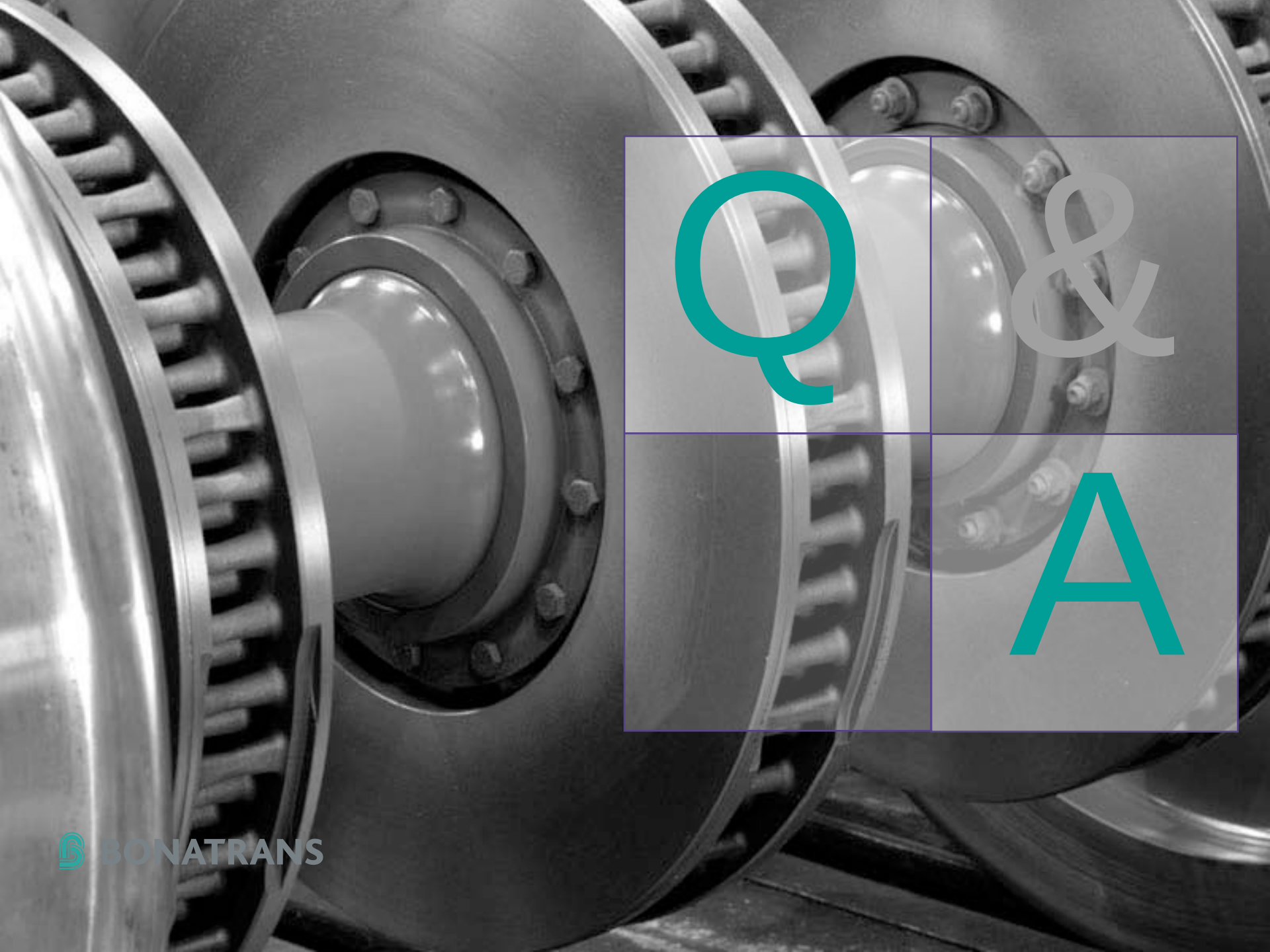

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