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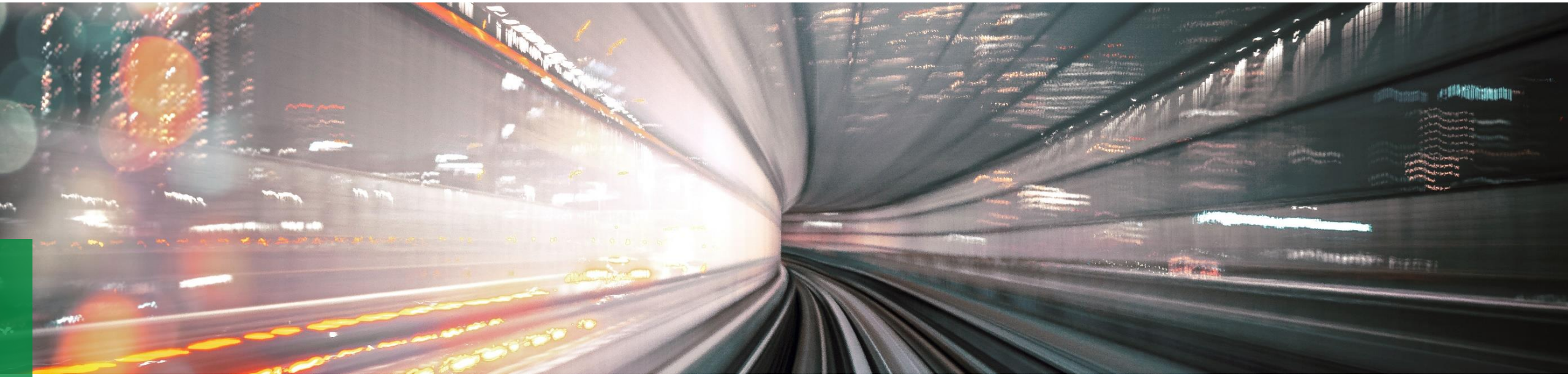

고속차량 엑슬베어링의 과거, 현재 그리고 미래 @ Schaeffler

We pioneer motion

01 Axle bearing in High speed train

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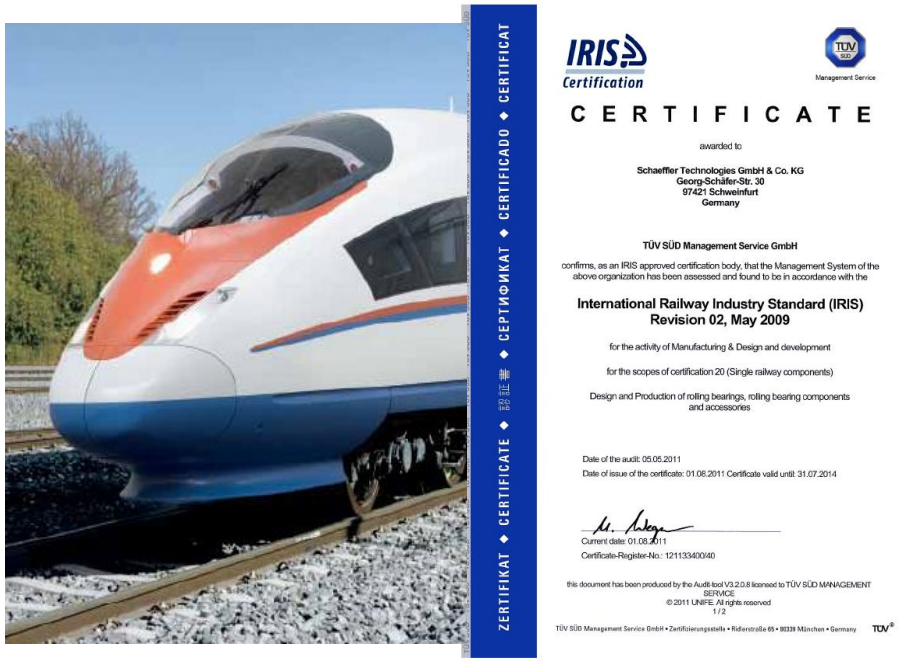
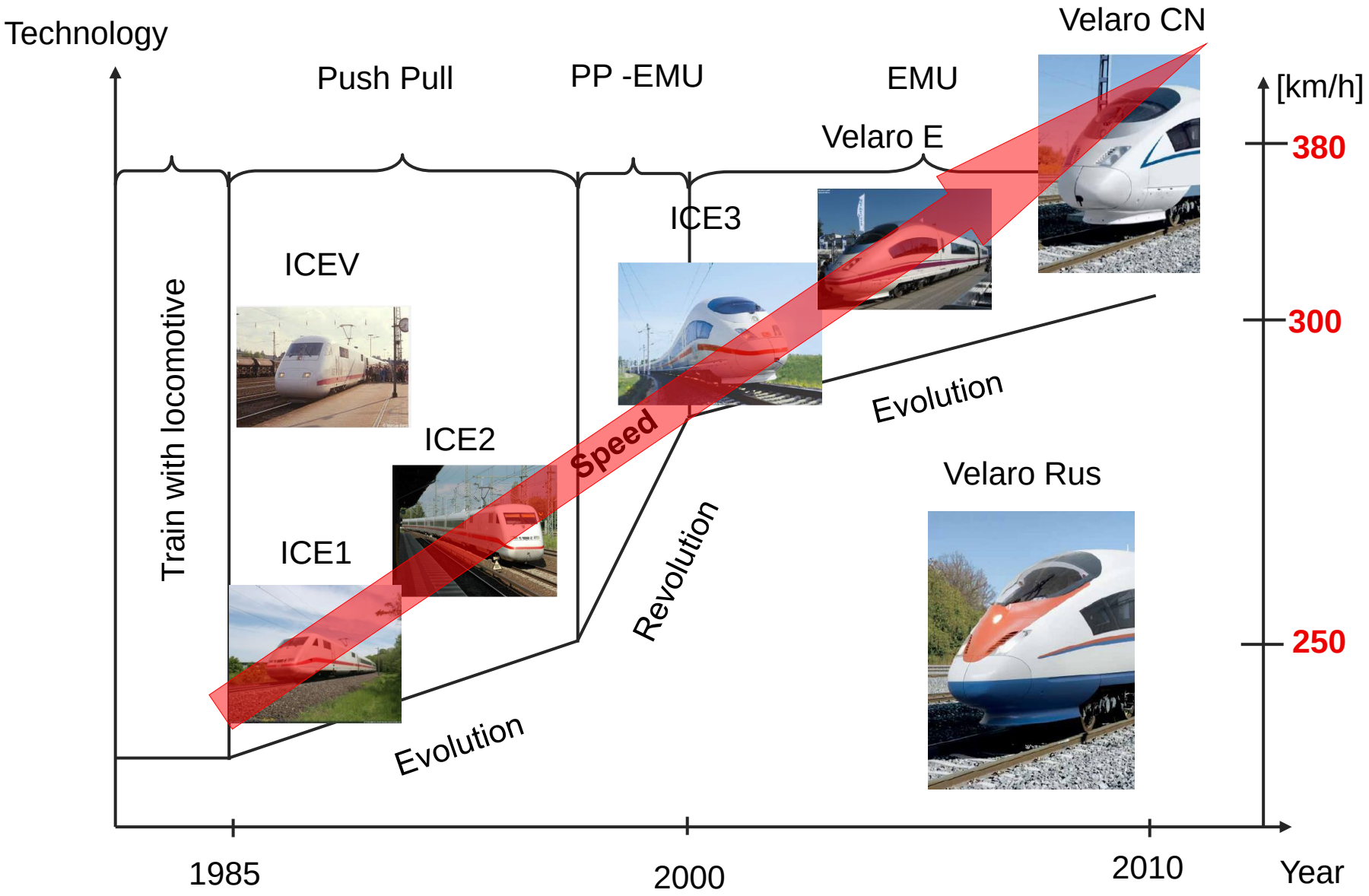
History

Since 1883

Today



High Speed Trains
Timetable



Push-Pull Trains – ICEV; ICE1 and ICE2

Push Pull Train – ICEV

Maiden voyage: 26th of Nov, 1985

Maximum speed: 317 km/h

Speed record: 406,9 km/h
(1st of May, 1988)

Push-Pull Trains – ICEV; ICE1 and ICE2

Push Pull Train – ICE1

In service since June 1991

ICE1 fleet: 60 (12 car) trains

Maximum speed: 280 [km/h]

Maximum service speed: 250 [km/h]

Axle load of power car: 20 [t]

Axle load of passenger car: 16 [t]

Push-Pull Trains – ICEV; ICE1 and ICE2

Push Pull Train – ICE1

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Bearing designation:

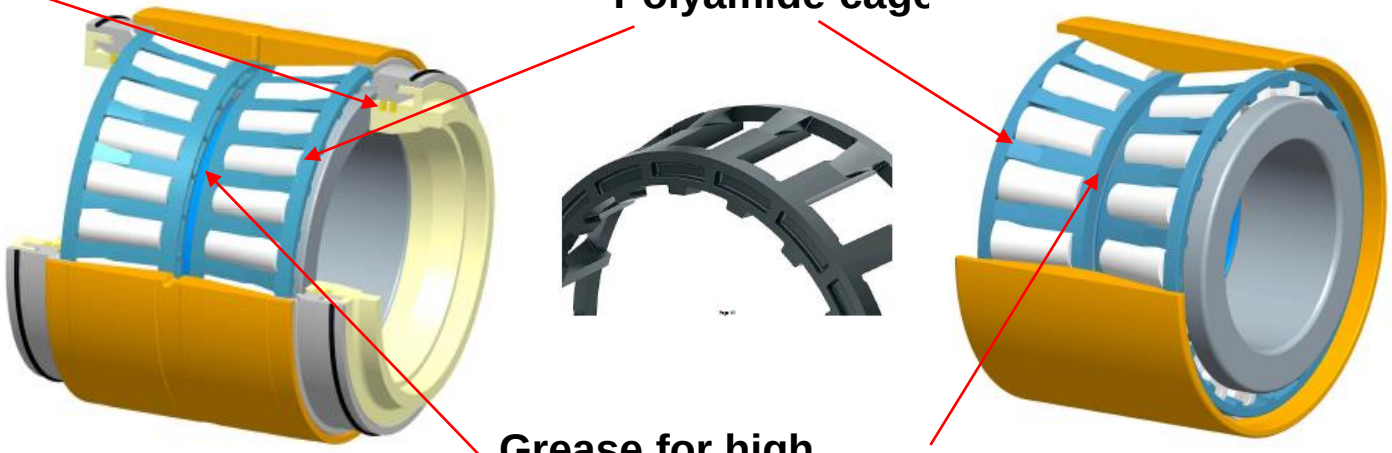
Z-575615.01.TAROL150/250-B-TVP

Bearing designation:

Z-574288.02.TAROL130/240-B-TVP

Lamellar rings

Polyamide cage



Grease for high speed application

Power car bogie

Push-Pull Trains – ICEV; ICE1 and ICE2

Push Pull Train – ICE2

In service since 1996

ICE2 fleet: 44 (8 car) trains

Maximum speed: 280km/h

Maximum service speed: 250km/h

- **One power car and one cab car for each train**
- **Two half trains may be connected to a long train**

Push-Pull Trains – ICEV; ICE1 and ICE2
Push Pull Train – ICE2

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Bearing designation:

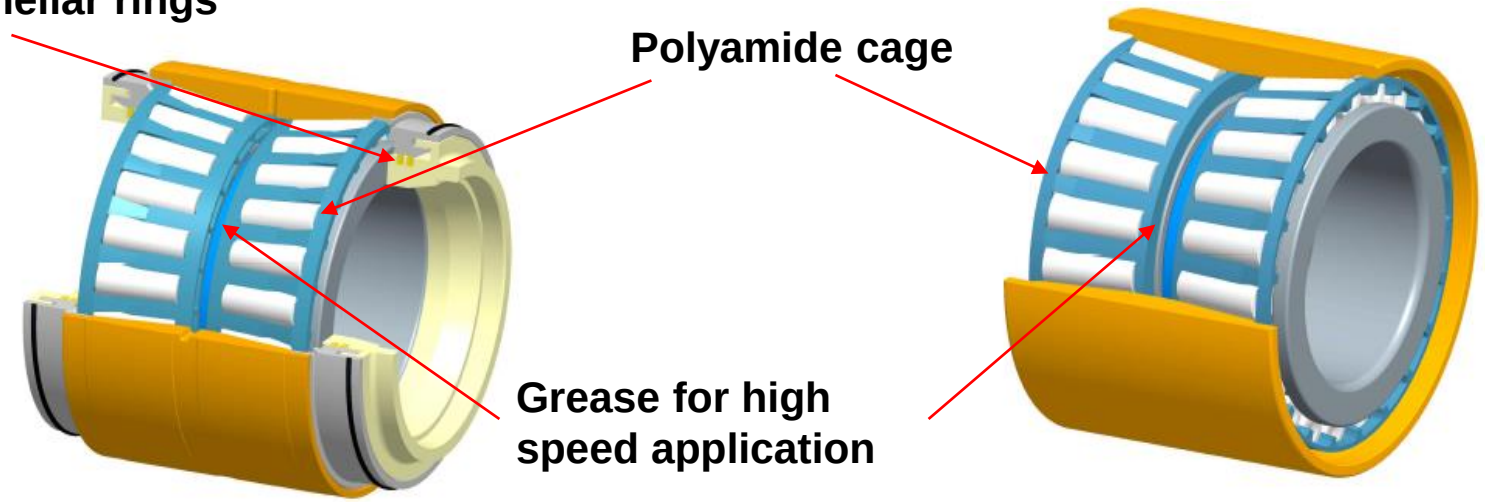
Z-575615.01.TAROL150/250-B-TVP

Bearing designation:

F-801420.TAROL130/230-B-TVP

Lamellar rings

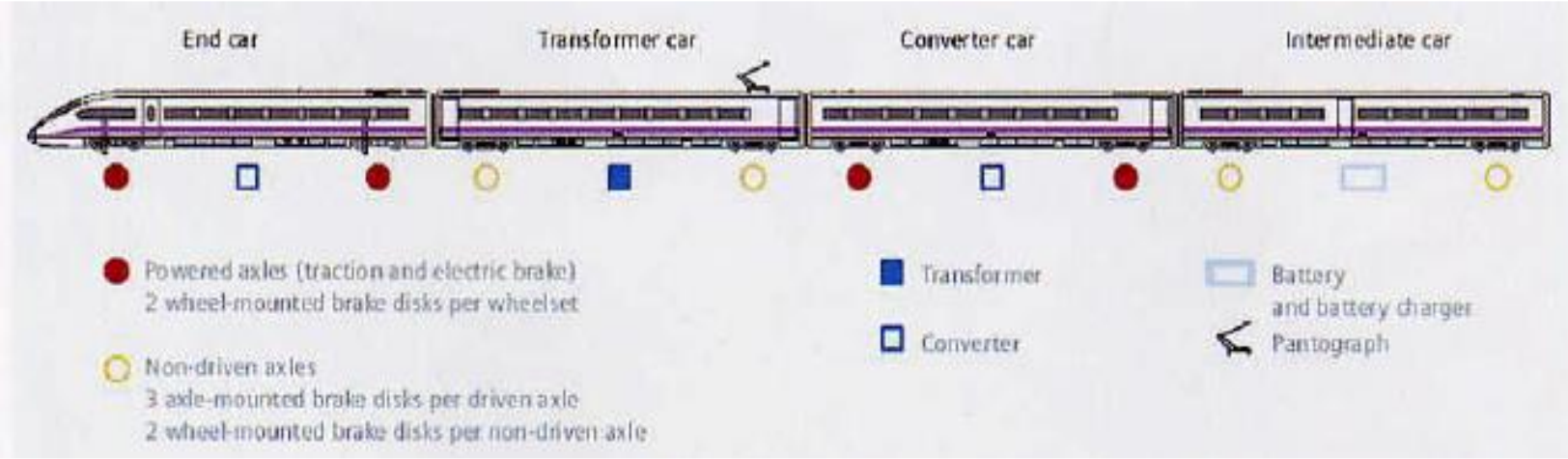
Polyamide cage



Grease for high speed application

Power car bogie

EMU Trains – ICE3; Velaro E; Velaro CN & Velaro Rus
Revolution from Push Pull to Distributed Traction EMU



Every second car has two power bogies with two driven wheel sets.

EMU Trains – ICE3; Velaro E; Velaro CN & Velaro Rus

Distributed Traction – ICE3

In service since 06/2000

High speed track – Frankfurt to Cologne since 08/2002

Maximum speed: 330 km/h

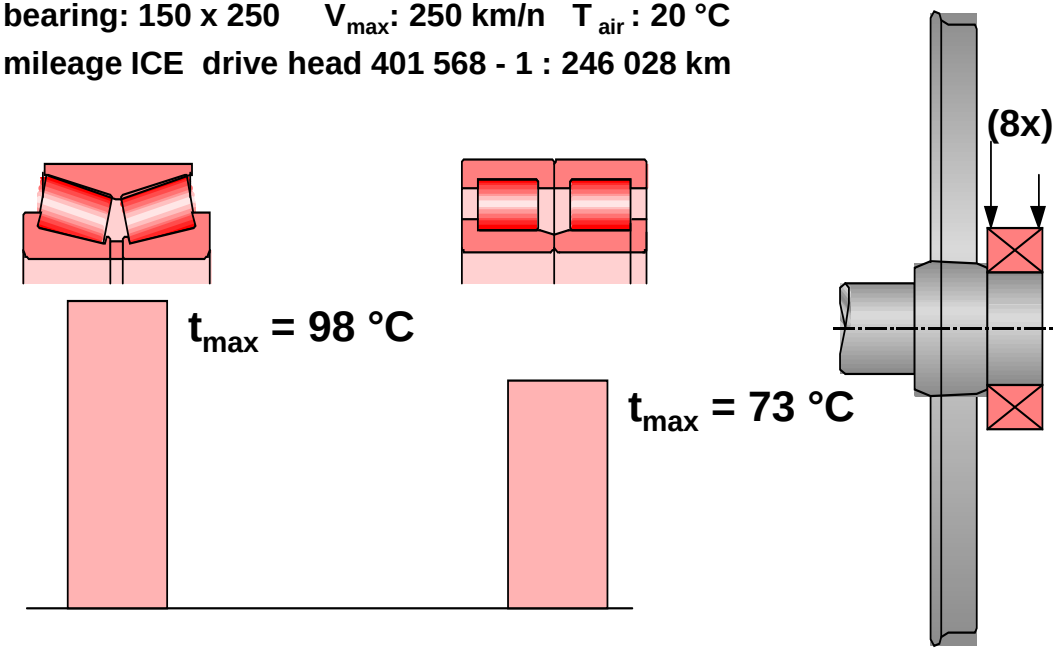
Maximum speed in service: 300km/h

ICE 3 Fleet:

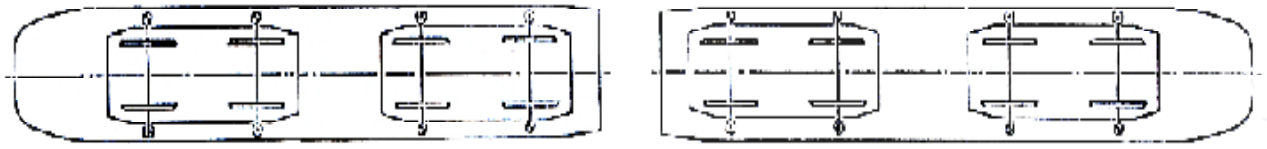
- **45-(8 car) trains in single system version**
- **27-(8 car) Trains in multi system version for trans border service in Europe.**

EMU Trains – ICE3; Velaro E; Velaro CN & Velaro Rus
Distributed Traction – ICE3 – Bearing

bearing: 150 x 250 V_{max}: 250 km/n T_{air} : 20 °C
mileage ICE drive head 401 568 - 1 : 246 028 km

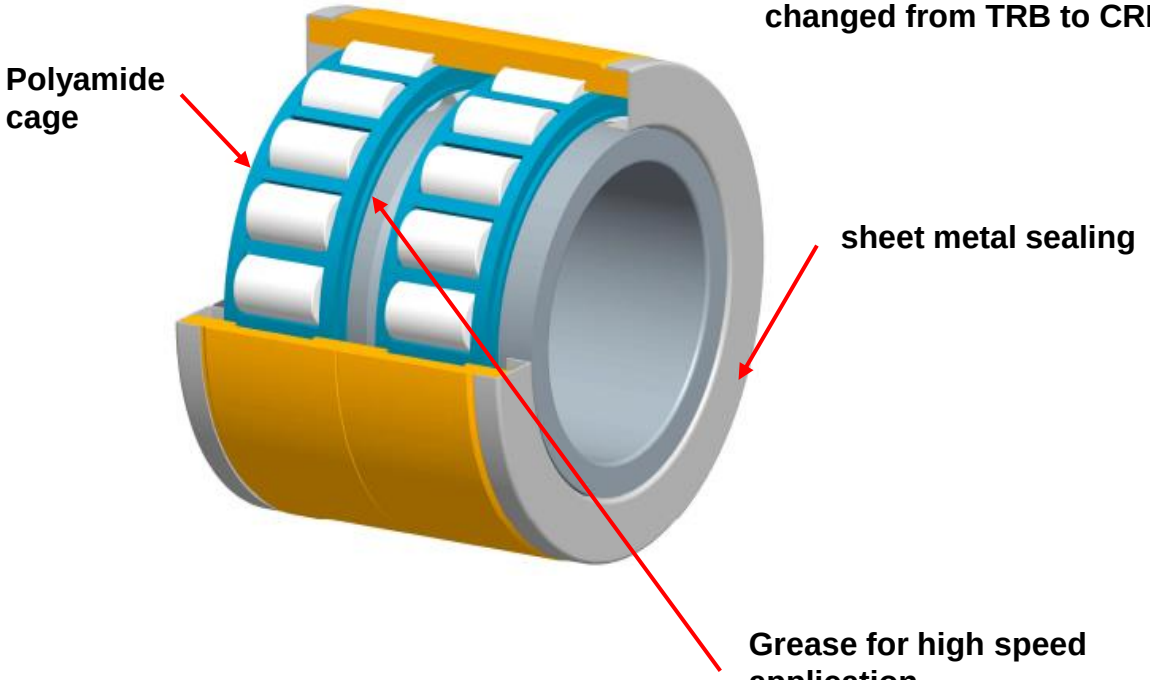


Position of temperature pickup



FAG Bearing designation F-808853.ZL

Due to higher speed the bearing design for ICE3 changed from TRB to CRB



EMU Trains – ICE3; Velaro E; Velaro CN & Velaro Rus
Distributed Traction – Velaro CN

In service since 08/2008

High speed track – Beijing to Tianjin

Maximum speed: 330 km/h

Maximum speed in service: 300km/h

Velaro CN Fleet:

- **60-(8 car) to be built in Germany and in China**

EMU Trains – ICE3; Velaro E; Velaro CN & Velaro Rus
Distributed Traction – Velaro CN – Bearing Comparison

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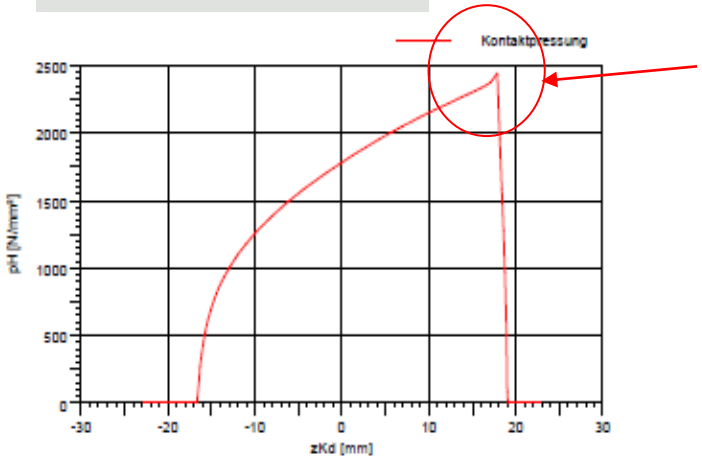
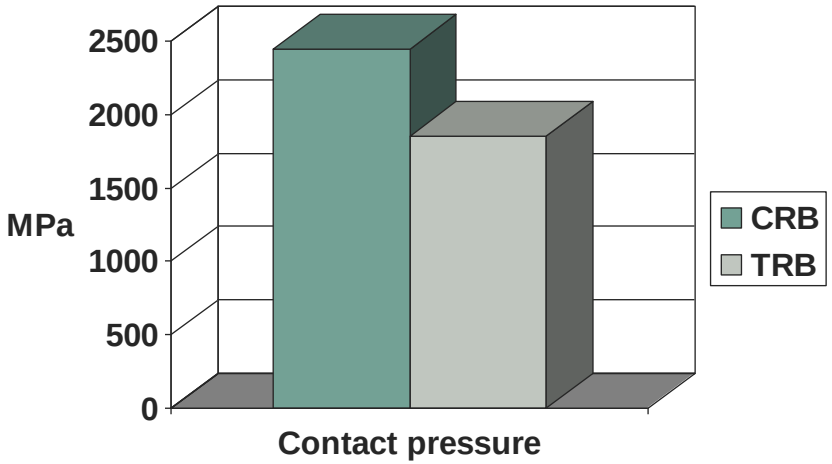
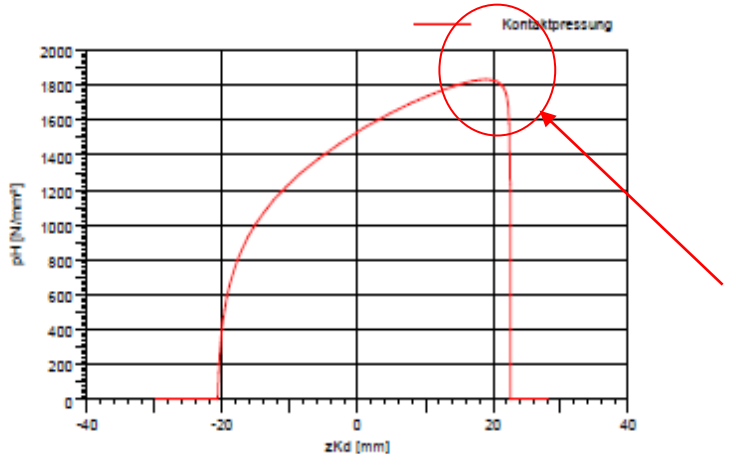
CRB F-808853.ZL



edge pressure

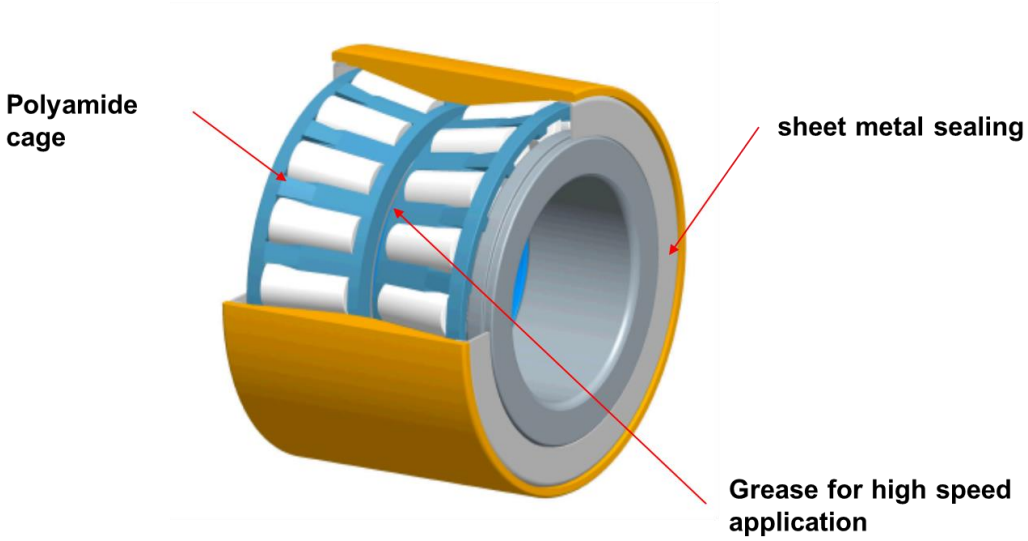


TRB F-807811.02.TAROL130/240-B-TVP



no edge pressure

FAG Bearing designation F-807811.02.TAROL130/240-B-TVP



EMU Trains – ICE3; Velaro E; Velaro CN & Velaro Rus
Distributed Traction – Velaro CN

Bearing Test according EN12082 – Test equipment

DAkkS
Deutsche
Akkreditierungsstelle

Deutsche Akkreditierungsstelle GmbH
German Accreditation Body

Entrusted according to Section 8 subsection1 AkkStelleG in connection with Section 1 subsection 1 AkkStelleGBV
Signatory to the Multilateral Agreements of
EA, ILAC and IAF for Mutual Recognition

Accreditation

The Deutsche Akkreditierungsstelle GmbH (German Accreditation Body) attests that the

Schaeffler Technologies GmbH & Co. KG
Prüffeld Bahn
Georg-Schäfer-Straße 30, 97421 Schweinfurt

is competent under the terms of DIN EN ISO/IEC 17025:2005 to carry out tests in the following field:

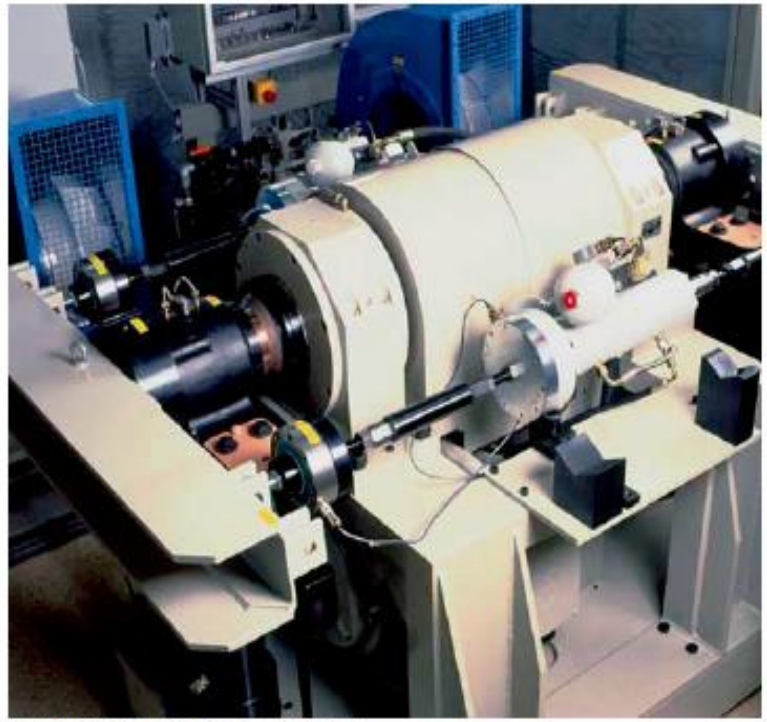
Performance testing of axleboxes - Railway applications

The accreditation certificate shall only apply in connection with the notice of accreditation of 16.06.2010 with the accreditation number D-PL-11127-01 and is valid until 15.03.2014. It comprises the cover sheet, the reverse side of the cover sheet and the following annex with a total of 1 page.

Registration number of the certificate: **D-PL-11127-01-00**

Berlin, 28.06.2010

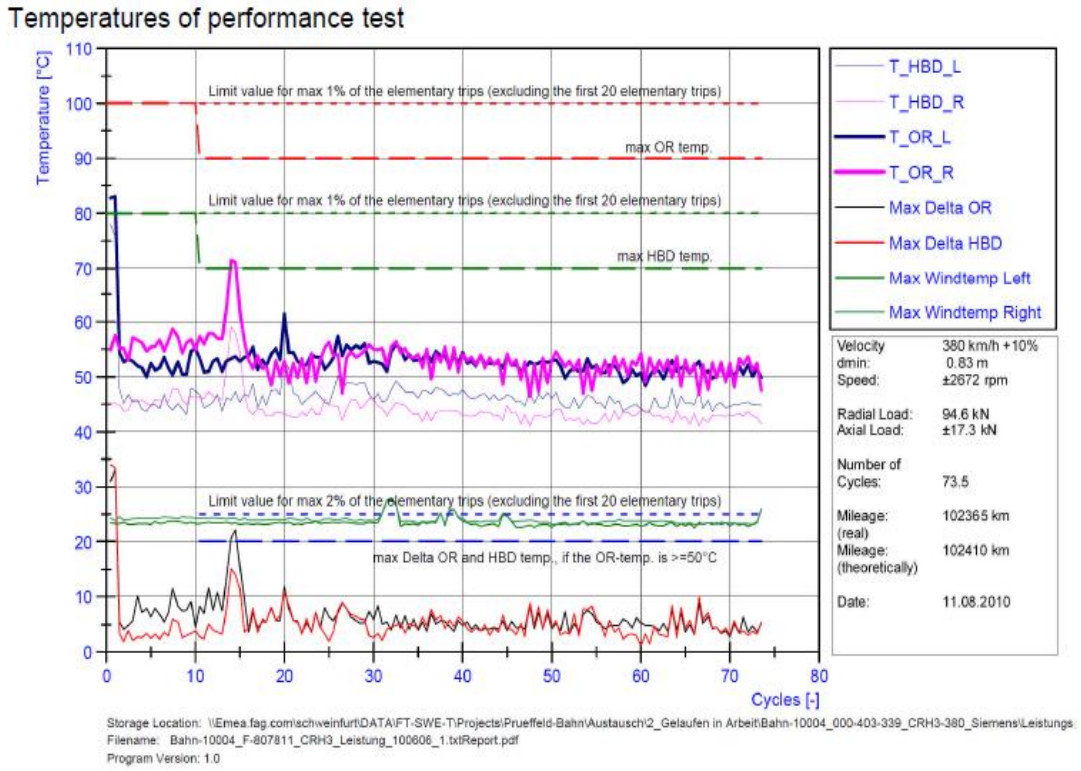
Dr. Thomas Facklam
Managing Director

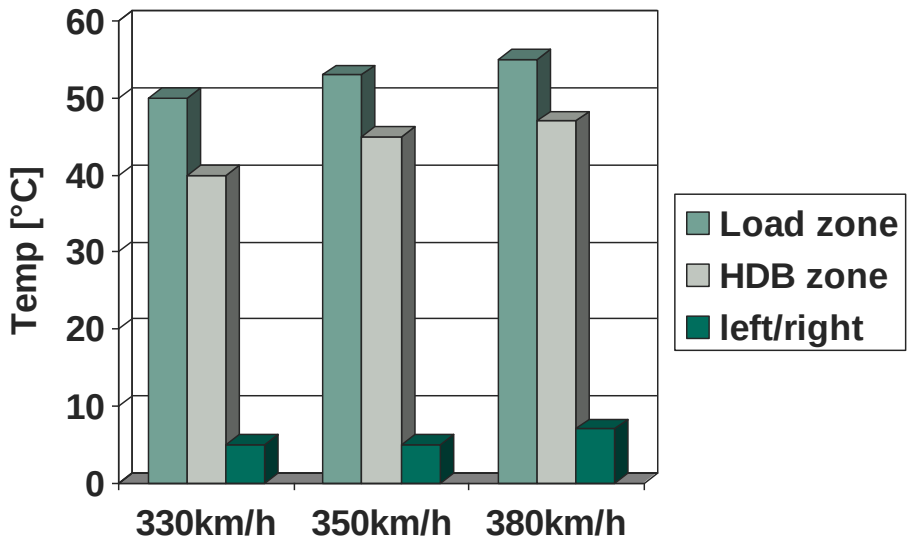


Standard-Prüfstand AN55: Nach Angaben von EMG gebaut.

EMU Trains – ICE3; Velaro E; Velaro CN & Velaro Rus
Distributed Traction – Velaro CN

Bearing Test according EN12082 – CRH3 third batch – v=380km/h – 100.000km





State of art High speed trains – Outboard axlebox

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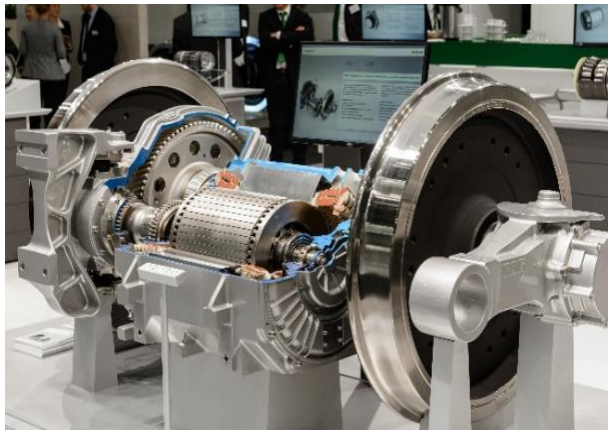

High-Speed-Trains China – "CRH3"(Velaro China)
"outboard axlebox arrangement"
v_max 418 km/h
nxdm 495 000 mm/min
F-807811.09.TAROL130x240-B-TVP
ARCANOL L055/L218

field-service

Requirements:
> temp-limits as per EN12082: 90°C at load zone
> Mayor overhauling > 1,4 Mio. km (established)
> online-temp reduction to < 70°C
> environmental temperatures -50°C …50°C

Evidences:
> performance tests as per EN12082 up to 1,2 Mio. km on test rigs AN55 and AN77
> reference field applications – ICE Middle Coach, AGC
> low-temp-initial-torque tests for L218 and L055
> water-tightness-tests acc. UIC515-5
> inspections during SG in-house overhauling – Schaeffler CARs

State of art High speed trains – Inboard axlebox

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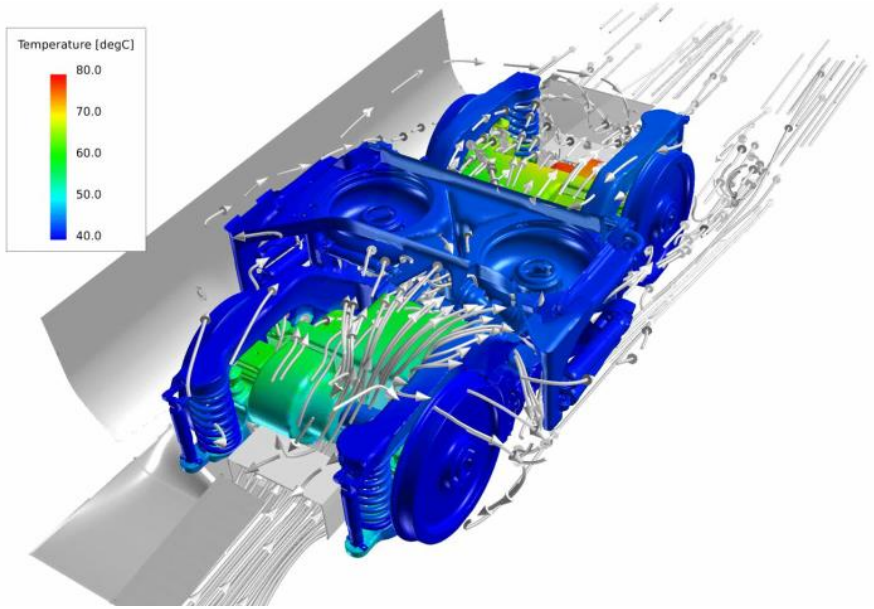
High-Speed-Trains USA – "Bright Line"
"inboard axlebox arrangement"
v_max. 396 km/h
nxdm 593 000 mm/min
F-620591.ZL
ARCANOL L218)
temp-limits as per EN12082: 90°C for load zone.

prototype-phase



Requirements:
> temp-limits as per EN12082: 90°C at load zone
> Mayor overhauling of axlebox bearing after 1,65Mio.km resp. 8 years (refurbishment concept)
> Replacement of axlebox bearing after 3Mio.km resp. 10 years ("use-till-scrap" concept)
> aerodynamic bogie-cover + inboard axlebox > reduced windchill impact
> temp-impact on axleboxes from break-discs + traction motor

Evidences:
> performance tests as per EN12082
> water-tightness-tests acc. UIC515-5
> simulation for heat-impact
> new design concept for high-speed-axleboxes

02 Axle bearing development process

Axle bearing 개발 방향

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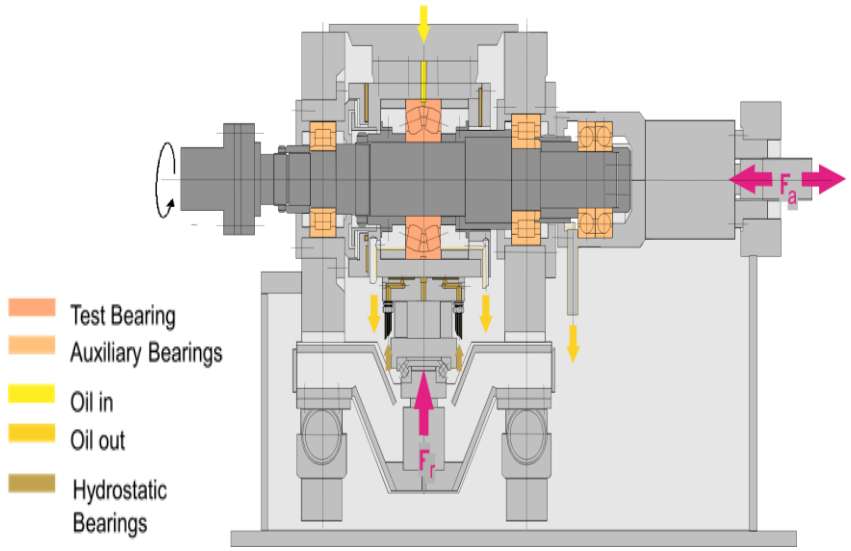
Established standard approach to determine frictional power losses

Bearinx

Quasi static bearing model for friction calculation:
- Internal geometry
- Speed and loads
- Lubricant properties of the base oil

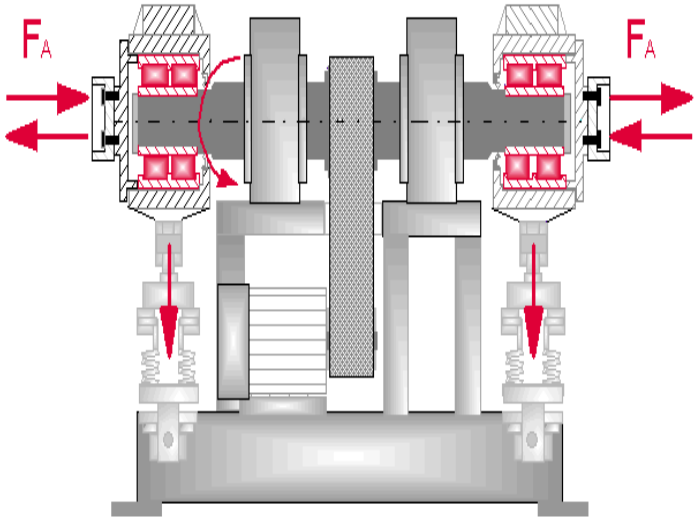
Caba3D

Dynamic bearing model for friction calculation:
- Internal geometry
- Speed and loads
- Lubricant properties of the base oil
- Dynamic effects



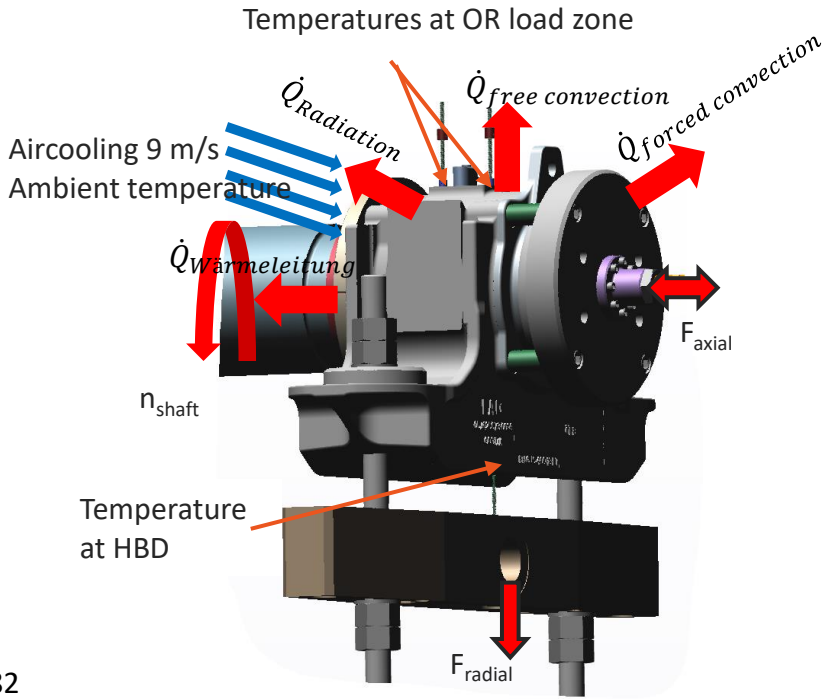
Precise friction measurement:
- Bearing unit only
- Installation case see sketch
- Speed and loads
- Oil lubrication, cooling by lubricating oil

Simple approach to estimate average frictional power loss



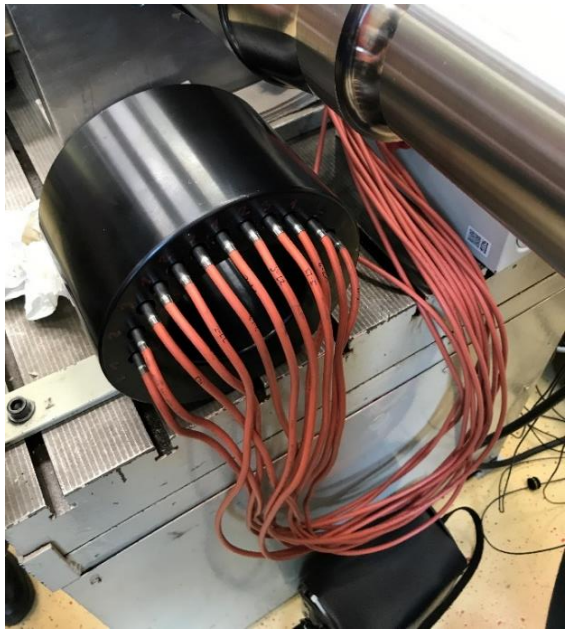
EN12082 Performance testing:

- Longterm testing with speed and loads acc. to EN12082
- Realistic test conditions: Original housing, grease lubrication, shaft, airstream cooling, etc.
- Temperatures of the bearings



Modeling:

Measured temperatures as result of frictional power loss and heat flow.



Hearting up test:

Frictional power loss is simulated by electrical heating. Temperatures are measured in EN12082 set up.

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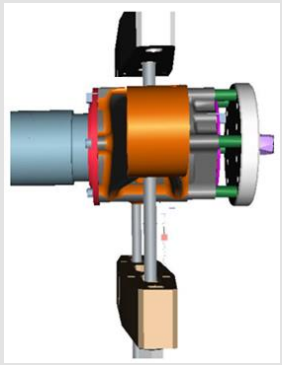
Appraoch the result between Test and calculation

Test machine: AN77-1

- Bearing temperature
- Input power
- Output power loss



Measuring data is compared to calculaton result by Bearinx

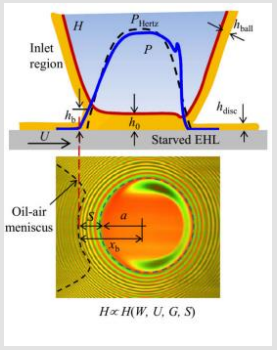
Calculation: Bearinx

- Frictional power loss
- Expected bearing temperature

Consideration the different reason between test and calculation

Compare test and calculation

- Consideration and compensate the influence factors



Comparison after applying the new influence considered in the calculation

Compare the re-calculation between test and calculation

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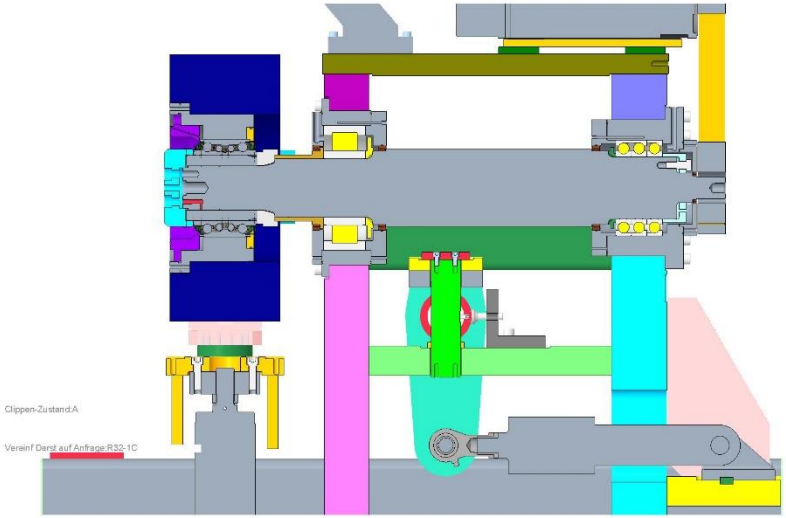
Further steps in determining frictional power loss

The modifications in frictional power calculation done in the simple approach are only valid for load case of EN12082 performance test. Next steps should be:

1. Measured bearing temperatures for load cases under real running conditions
2. Direct determination of power losses by measuring bearing torque at load cases of real running conditions
3. Improving and validation calculation model for different load cases and operating conditions



03 Service solution beside Bearings

Railway Condition Monitoring System (RCMS)

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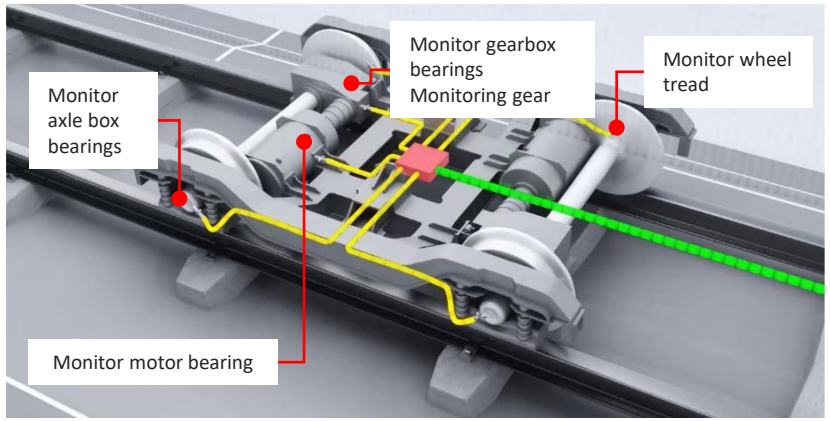

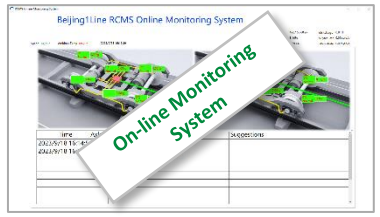

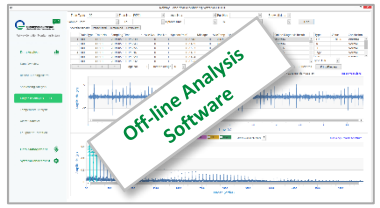

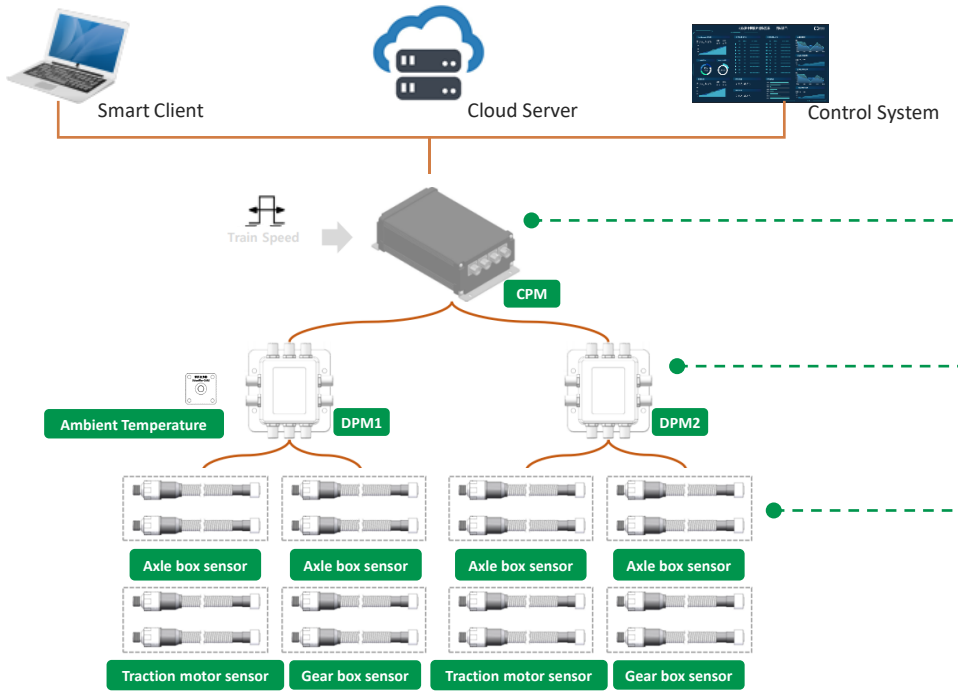

CPM:
- Calculation & Processing
- Analysis of Failure Parts
- Real-time Diagnosis
- Damage Level Alarm
- Raw Data Storage
- Diagnosis Result Upload

DPM:
- Vibration and Temperature Signal Sampling
- Analog Signal Digitalization
- Ethernet Data Transmission

Complex Sensor:
- Bearing Vibration Measurement
- Bearing Temperature Measurement

Railway vehicles Condition Monitoring System based on Resonance Demodulation Technology

—— Comprehensively monitor and diagnose the working face and wheelset tread of key components such as running part bearings and gears, and conduct early warning and accurate positioning of faults

- ✓ **Multi-Channel** Parallel Processing, Fast System Response
- ✓ **On-line** Diagnosis Alarm & **Offline** Data Analysis
- ✓ Intelligent Diagnosis Algorithm Based on Advanced Analysis Strategy with **High Accuracy of Online Fault Diagnosis**
- ✓ Auto Generating Report of Status Diagnosis, and Upload to Server
- ✓ Expandability of System Functions，Predict Bearing Remain Useful Life and Full Life Cycle Management such as **Customized** Monitoring Wheel Polygonization Fault, Dynamic Setting of Temperature Alarm Threshold, Predict and Evaluate Bearing Remain Useful Life, Estimate the Size of Natural Spalling Failure, Suspension System Fault Diagnosis, Stability and Comfort Monitoring, Instability and Derailment Detection, Rail wave grinding detection…

Acoustics and Thermal Monitoring System (ATMS) - Rail Transit Application

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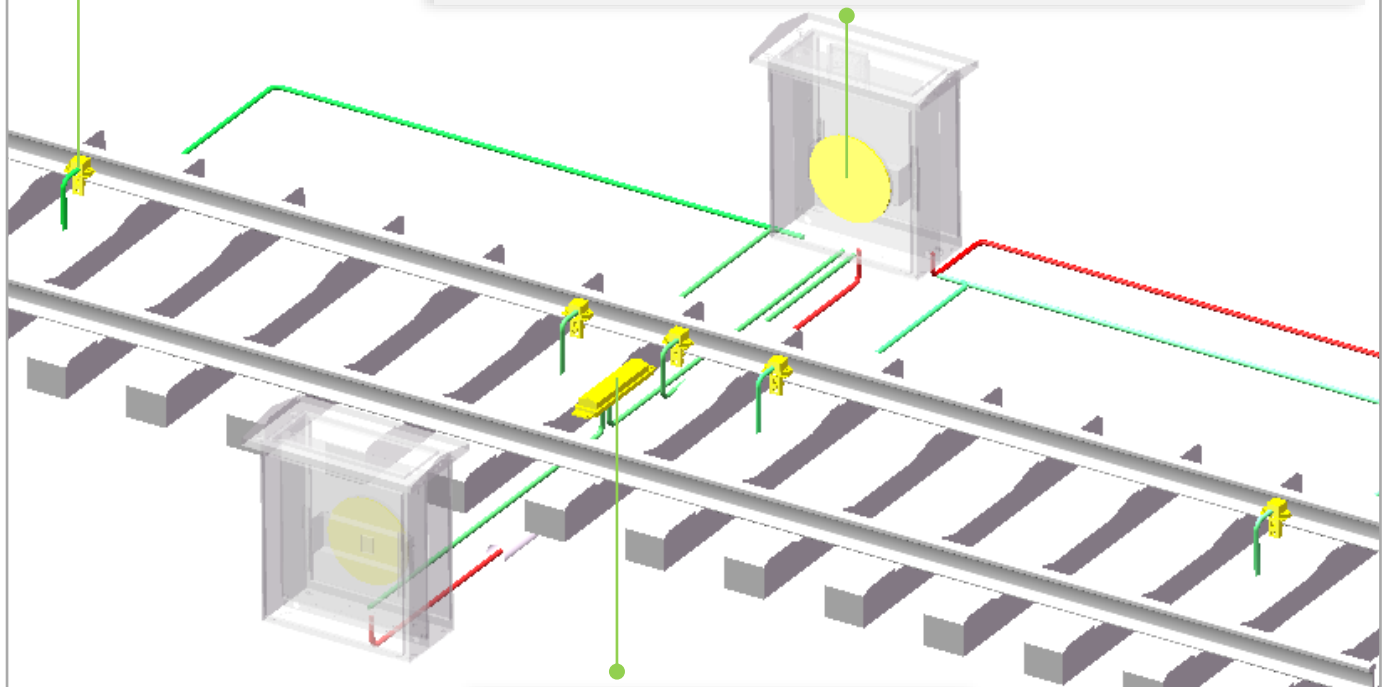
Sensor: Recognize vehicle passing and wake up the system

Acoustic Camera:

- **Real-time calculation and analysis of noise signal frequency:** Combined with equipment structure and running state, real-time diagnosis of key components
- **Sound source visualization technology:** Real-time dynamic display of noise source location within the image range
- **Intelligent cloud platform control:** Real-time management and monitoring



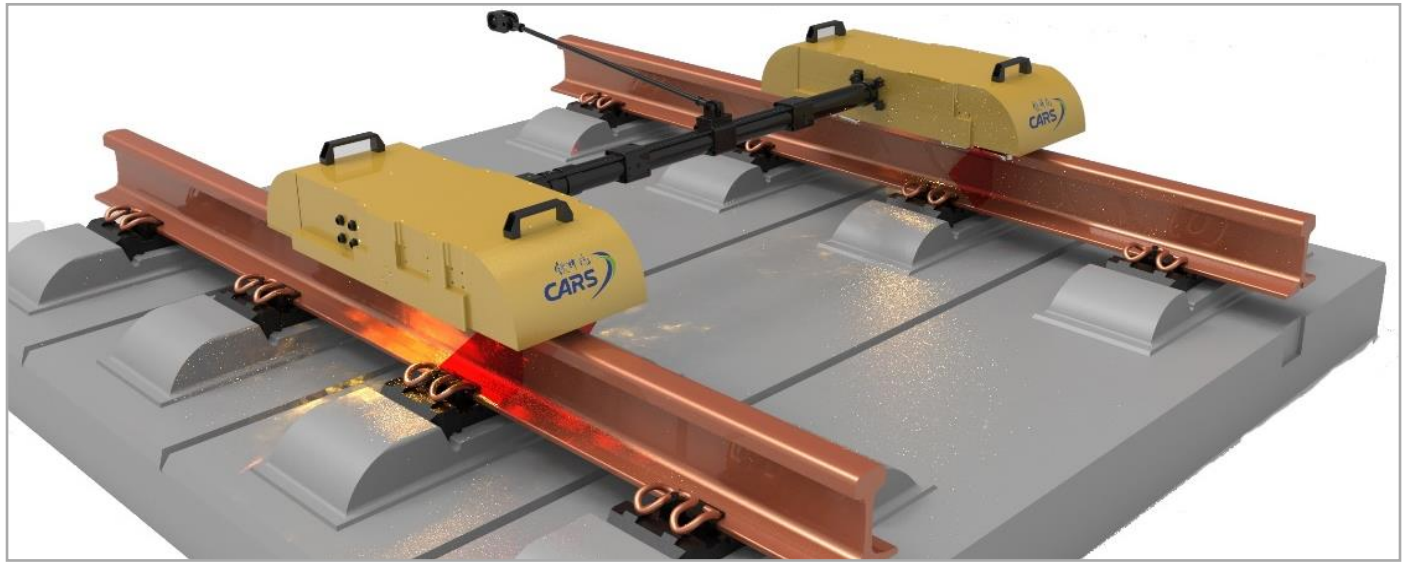
AEI sensor: Identification of vehicle number and transmission to industrial computer

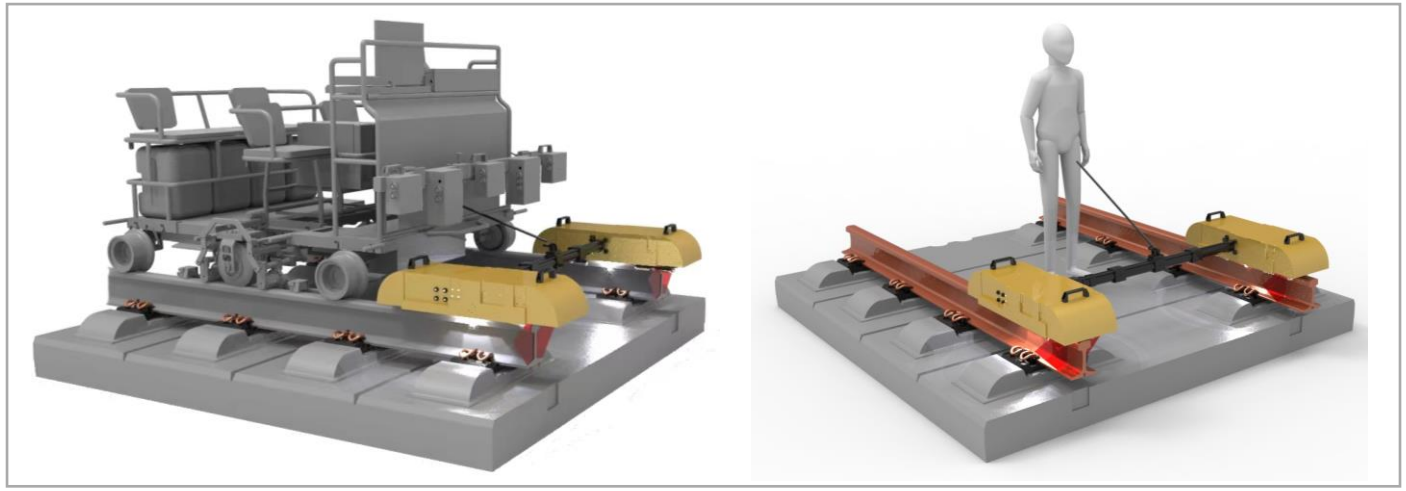
Trackside Monitoring System based on Microphone Array

—— Identification of abnormal noise and temperature, fault diagnosis

- ✓ **High integration and small occupied area:** The system uses a digital microphone array with small size acoustic acquisition unit and the wheel signal and vehicle information acquisition function are integrated.
- ✓ **Spatial filtering can be realized:** The beamforming technology can follow the wheel movement to collect noise signal, which can effectively reduce the influence of environmental noise and improve the signal-to-noise ratio of fault signal.
- ✓ **Real-time diagnostic analysis:** The frequency components of running noise can be calculated and analyzed in real time, and the state of key components can be diagnosed.
- ✓ **Real-time display of noise source location:** The sound source visualization technology is used to display the position of the noise source in the image range in real time, and different noises can be monitored in real time by referring to the frequency range.
- ✓ **Intelligent automatic control of outdoor cabinets:** The rolling shutter door can be automatically controlled according to weather conditions and vehicle operation time, and the fan can be automatically turned on to cool down according to the equipment temperature.
- ✓ **Extensible system functions:** The thermal imaging camera can be integrated to monitor the temperature of the running part graphically, and the key parts of the running part can be detected with computer vision technology.

Rail Condition Detection Car





Rail Condition Detection Car with unpowered detection scheme

—— Integrating the profile, wave corrugation, eddy current and rail surface status inspection subsystems on the miniaturized running device with various working modes such as hand pushing, dragging and self-running with convenient and simple operation

- ✓ **Detection items:** Rail profile, wave corrugation, rail cant, surface crack and depth, rail surface visibility defects
- ✓ **Detection speed:** 3-15km/h
- ✓ **Measurement mode:** Non-contact continuous measurement
- ✓ **Profile detection accuracy:** ≤±0.03mm
- ✓ **Crack measurement accuracy:** ±0.15mm (depth)
- ✓ **Deepest crack could be measured:** 5mm
- ✓ **Defect identification rate:** ≥90%
- ✓ **Defect false alarm rate:** ≤5%
- ✓ **Image acquisition accuracy:** ≤0.1mm (landscape), ≤0.6mm (portrait)
- ✓ **Detection data is automatically recorded**

Customized Case 2: Automatic inspecting for freight wheel and axle

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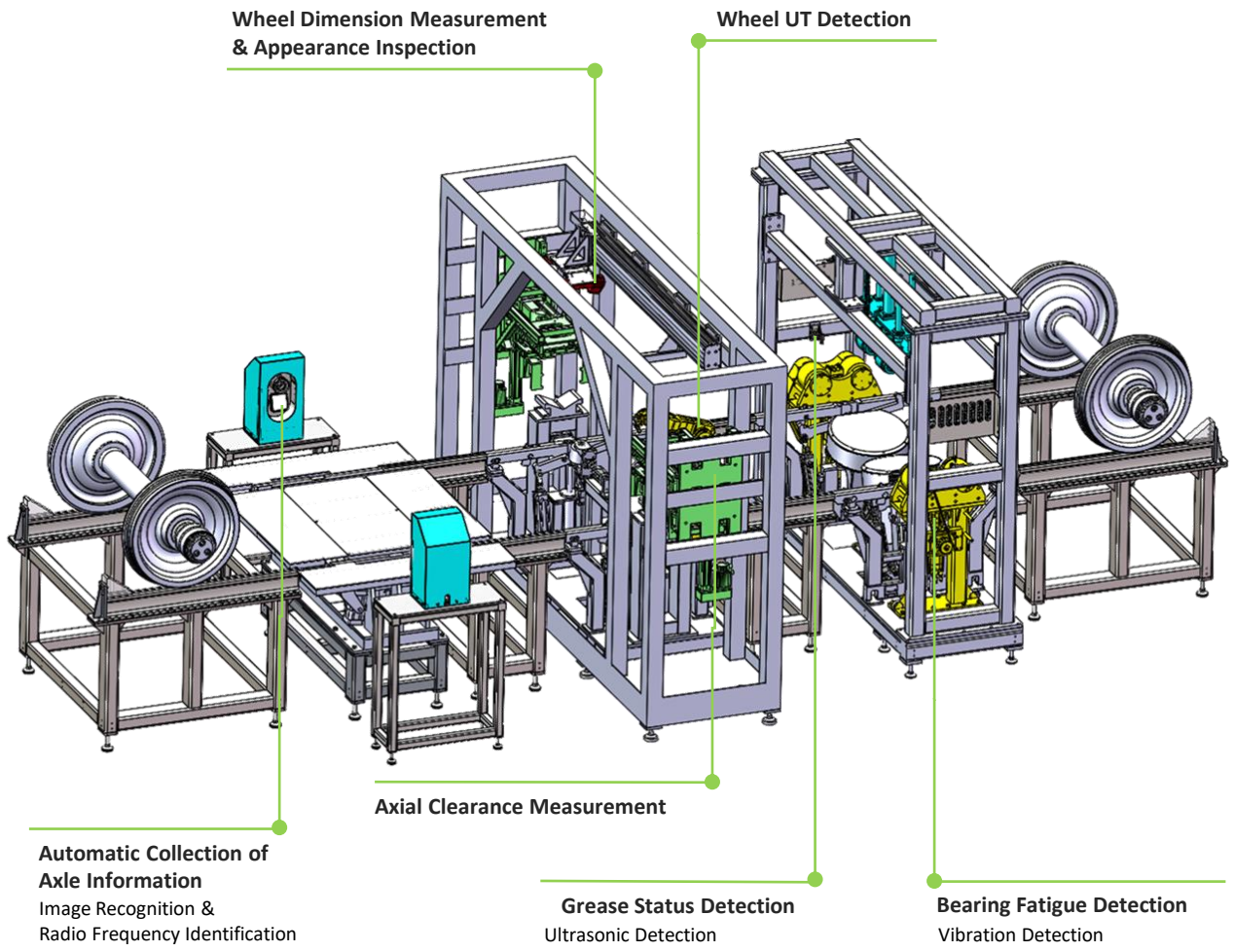

Automatic inspection equipment for freight wheel and axle based on intelligent image recognition system, phased array ultrasonic flaw detection and NVH detection technology

—— Comprehensively collecting the information of axle sign board, wheelset profile size, surface state and bearing state and making reasonable judgment on the evaluation of wheel and axle's maintenance process

- ✓ **Sign board information recognition:** The self-learning function of image recognition component is used to read the engraving information on the surface of the sign board, the radio frequency identification component is used to obtain the manufacturing, assembly and maintenance information of the wheel and axle equipped with radio frequency electronic tags.
- ✓ **Wheelset dimension information acquisition:** The non-contact laser detection module is used to measure the profile size of two wheels, the inner distance of the wheelset and the diameter of the axle.
- ✓ **Wheel surface state inspection:** Image recognition technology is used to conduct algorithm training and adjustment of typical wheel damage or defect topography to achieve accurate recognition and grasp of abnormal features on the wheelset surface. At the same time, probes integrated with multiple ultrasonic sensors are used to evaluate the internal damage of the wheel tread under the clamping action of industrial robots.
- ✓ **Bearing axial clearance measurement:** The servo control system is used to automatically measure the bearing axial clearance and read the data.
- ✓ **Bearing internal technical status detection:** The sensor is used to collect the noise signal and vibration signal of the rolling bearing, select a specific signal analysis method to extract the time domain and frequency domain characteristics, and fuse the main parameters of vibration and acoustics for judgment, so as to give the bearing quality grade information.

We pioneer motion