Mobile mechanized ultrasonic testing on wheel set axles with longitudinal drill

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Abstract. Rail-mounted vehicles should be dependable, reliable and safe for the availability of operation. At the same time the cost pressure constantly increases while continuous maintenance has to be ensured. AREVA Qualicon Services enables the Private Railway Companies (PRC) to conduct and complete mechanized ultrasonic testing without any financial investments for any testing systems and/or testing staff. This essentially increases the safety of testing activities and reproducibility towards manual ultrasonic testing.

The testing concept guarantees a high degree in flexibility in regards to different kinds of drilling diameters, shaft geometry and testing/examination locations.

In this presentation the development of the mobile mechanized ultrasonic testing and the applied testing technology as well as reports of first practical experience will be explained.

Preface

As a result of a privatized and restructured railway market in Germany, a diversified field of Private Railways Companies (PRC) arose from the formerly state-owned system. Besides a reliable and safe operation of their trains, the PRC are facing maintenance issues as a major challenge. Securing compliance with technical safety standards for railway vehicles is immanent to maintenance activities and, therefore, part of their current core business. Various non-destructive testing (NDT) methods are being applied in the course of these maintenance programs. This paper introduces AREVA’s solution to this challenge: mobile mechanized ultrasonic inspections of longitudinal drilled wheel set axles (LDWSA).

It is our goal to create added value for PRC with our flexible and mobile mechanized UT-System. Wheel set bore diameters ranging from 30mm to 90mm can be easily inspected due to the modular design of the inspection system. Reproducibility and comparability of inspection results is guaranteed due to long-term storage of acquired raw data. Potential false call rates are drastically minimized due to removal of the human factor via mechanized data acquisition. Moreover higher inspection speed leads to a higher productivity in tight maintenance schedules. All inspections are under the umbrella of an independent NDT-inspection agency according to DIN 27201-7[1].
1. **Definition of the inspection task**

The requirements for a mobile inspection system derive from five major aspects: NDT method, NDT application for dedicated designs, system hard- and software, operational aspects and compliance with German inspection codes and standards.

Key for successful operational use of the system was to develop a versatile but robust system, taking into account the size and weight to allow easy transportation. Another important criterion was the flexibility in terms of adaptation to different LDWSA bore diameters. The NDT application needs to take into account that there are LDWSA designs with different OD contours whilst the ID bore diameter remains the same.

The final system design allows one person to easily modify the system in a very short time.

2. **Codes and standards**

DIN 270201-7 is the applicable guideline for maintenance NDT of railway vehicles in Germany. The following subchapters display a non-official translation from the German DIN 270201-7.

2.1. **Preface**

The maintenance of railway vehicles requires non-destructive testing of safety-relevant parts and components including their welded joints as determined in OEM maintenance plan or PRC maintenance guidelines. Further operation of these vehicles shall be subject to the regulations of this standard.

2.2. **Inspection**

Inspection shall be performed at maintenance workshops / NDT test centers by qualified NDT personnel. Independent NDT service providers shall be treated in the same way as maintenance workshops / NDT test centers.

Workshops and test centers shall be equipped with all necessary means, such as qualified inspection procedures, qualified equipment and qualified inspection personnel.

2.3. **NDT inspection procedures**

Inspection of safety relevant parts, assembly groups and components require a qualified NDT procedure validated by a NDT competence center.

3. **Presuppositions**

In order to comply with requirements of DIN 270201-7 as given above, organizational and technical presuppositions needed to be put into place.
3.1. Organizational presuppositions

In a first step the existing individual UT qualification and certification for NDT services according to DIN EN ISO 9712 (“Services for production and maintenance”) needed to be extended to the railways industry sector.

After this extension and first hands on experiences in this industry sector it was possible to register as a NDT center of competence in accordance with DGZfP guideline ISB02. The existing DIN EN ISO 17025 accreditation (accredited testing laboratory) was a solid ground for the conducted audit by “DB Systemtechnik Kirchmöser”.

3.2. Technical presuppositions

A validated NDT inspection procedure required to develop test programs for the different LDWSA design types. System parameters were set with a certified LDWSA test set. The NDT inspection procedure, test programs and the inspection system was validated by a NDT center of competence.

4. NDT concept

For calibration, parameter setting and re-check purposes built-in state of the art NDT systems at maintenance workshops are using original LDWSA sets with artificial defects (secant cut t=2,0mm) for each and every design type. This may lead to having several test specimens for the same LDWSA bore diameter and multiplying the amount in case different bore diameters are to be inspected.

Our aspiration with the new system was to avoid the permanent necessity of these manifold test specimens in their original length. We aimed at finding one certified LDWSA test set that allows transferring NDT parameters taking into account geometrical influences and sensitivity settings. Therefore we conducted measurements on various LDWSA test sets with the same bore diameter. This work has shown that a principle transfer of geometrical influences is feasible. Results of this work need to be taken into account for different LDWSA bore diameter designs.

In a first step raw data for a proof-sample C-scan is acquired from a certified LDWSA test set with full original length. Right after, a second set of raw data for a proof-sample C-scan is acquired from a shortened certified LDWSA test set with the same UT system parameters.

Due to this proceeding it is possible to compare the specific LDWSA with the shortened, more generic LDWSA and to validate necessary transfer parameters. For operational use this enables the NDT inspection to use the smaller LDWSA for mobile applications instead of the longer and heavier original LDWSA.

Moreover, several smaller LDWSA of different design types can be loaded into the service truck with a tremendously decreased overall weight compared to full-length LDWSA. The NDT System and Team are more versatile in their application range and independent from fixed workshop structures.
5. **Introduction of the inspection system**

5.1 **System set-up**

A highly robust base-cart functions as platform for this modular system. On the one hand, the cart was designed for versatile movement. On the other hand, it acts as a highly solid foundation for the system.

Mounted on this cart you will find two main modules that are interconnected via a multipurpose cable chain. The main control and electronics cabinet features the UT platform as well as all needed control unit electronics. A Lap-Top computer can be connected to the system and be set on top of the cabinet. The second module is the NDT module. It features the UT transducers and a two-axis manipulation that allows a helix movement. Almost all kinds of LDWSA bore diameters can be inspected with its three different tool heads and contact technique transducer sets (30mm, 40-60mm, 60-90mm). Changeover to a different tool head only takes a few minutes and can be done by a single operator.

With this system design it is possible to inspect a LDWSA height of up to 1.4m on vehicles right on the main tracks.

5.2 **Inspection process**

The maintenance workshop has to prepare the vehicle for inspection. Therefore, the bearing caps of the wheel set axles are being removed to make both frontal areas accessible. After a preliminary cleaning of the LDWSA the inspection procedure can be started. Additional maintenance staff is not needed till the end of the inspection.

At first, a vacuum suction cap connects the NDT module to the front side of the LDWSA. No additional connector flanges are required.

After the mechanical connection to the LDWSA system parameters and test programs can be loaded to prepare for the data acquisition. The tool head is driven to the very end of the LDWSA to begin the acquisition. Oil is used as a coupling agent to guarantee a continuous and homogeneous coupling. The data is being acquired by a helix meander movement on the way back to the front end of the LDWSA. The bore hole is sealed to prevent coupling oil from accessing the axle bearing.

Acquired data is being displayed as A- and C-scan and can be viewed online. Moreover, it is possible to evaluate the signals of every transducer by switching view into single transducers view. Of course all raw data and A- and C-scan are being stored on a HDD for offline analysis and archiving purpose.

5.3 **LDWSA design types and inspection areas**

The software features a converter that can read LDWSA designs as a CAD file (e.g., .dxf). This obviates time-consuming manual programming and reduces transfer errors (human factor). Once the data is loaded, geometrical influential parameters can be taken into account and the systems parameters can be set.
5.4 Data analysis and documentation

In accordance with the NDT procedure data is being analyzed in a C-scans. After the Inspector finished his analysis, documentation is fully automated and a report is being generated.

For comparison with former recurrent inspection results it is possible to load a second C-scan to the same screen.

![Inspection system](image)

6. Practical experience

The first inspection of a LDWSA for German PRC was also used as a validation of the system concept and performance demonstration with a NDT center of competence.

As a result of this the mobile mechanized UT systems showed to be a full success. The work performed on sensitivity and influential parameters transferability paid off and all geometrical influences were taken into account correctly.

From an inspection under real-life conditions it was possible to gain information on inspection time and overall productivity. The overall intervention took 3.5 hours – less than expected (inspection task: train type “Desiro” with 6 LDWSA).

With this new productivity benchmarking it is possible to determine the maintenance down-times due to NDT for a vehicle fleet. Table 1 shows the time required for NDT maintenance of full trains and full fleet of a German PRC. Table 2 shows the time needed for the same vehicle fleet for manual testing. The comparison shows that the time needed is 3 times higher.
Table 1: NDT maintenance duration with our mobile service

<table>
<thead>
<tr>
<th>Train type</th>
<th>Number of axle per train</th>
<th>Number of trains</th>
<th>Testing time per train in [h]</th>
<th>Testing time of full fleet in [h]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Talent 2</td>
<td>8</td>
<td>20</td>
<td>4,8</td>
<td>96</td>
</tr>
<tr>
<td>Talent 2</td>
<td>12</td>
<td>15</td>
<td>7,2</td>
<td>108</td>
</tr>
<tr>
<td>Lint 41</td>
<td>6</td>
<td>52</td>
<td>3,6</td>
<td>187</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>Total testing time of one cycle for complete rolling stock:</strong> 391</td>
</tr>
</tbody>
</table>

Table 2: NDT manual testing

<table>
<thead>
<tr>
<th>Train type</th>
<th>Number of axle per train</th>
<th>Number of trains</th>
<th>Testing time per train in [h]</th>
<th>Testing time of full fleet in [h]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Talent 2</td>
<td>8</td>
<td>20</td>
<td>14</td>
<td>280</td>
</tr>
<tr>
<td>Talent 2</td>
<td>12</td>
<td>15</td>
<td>21</td>
<td>315</td>
</tr>
<tr>
<td>Lint 41</td>
<td>6</td>
<td>52</td>
<td>10,5</td>
<td>546</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>Total testing time of one cycle for complete rolling stock:</strong> 1.141</td>
</tr>
</tbody>
</table>

7. Summary and conclusion

It is a true success story. The highly versatile, flexible and mobile mechanized UT system creates an attractive bundle of added value for the customer:

- Productivity increase by shortening of NDT maintenance down-times
- Overall maintenance improvement – parallel activities are possible
- Externalization of NDT scope – reduction of operational and capital expenditures
- Reduction of necessary LDWSA test specimens (CAPEX)
- PRC do not need to be accredited as a testing center – QM cost reduction (OPEX)
- Workshop utilization gains a new lever through a mobile system to be used outside of a workshop
- Short changeover time between different vehicle / design types
- Higher flexibility in strategic purchasing of LDWSA design types

AREVA Qualicon managed to reach all goals that were set for this product development and succeeded to implement all technical and organizational changes. The intense product development, NDT staff training and certification are showing to be a top benefit for the inspection. With this new service AREVA Qualicon became the only versatile, reliable and economically attractive NDT service provider for longitudinal drilled wheel set axles.
References

[2] DIN EN ISO/IEC 17025: General requirements for the competence of testing and calibration laboratories