# Precision Wrenching for Rails

## DB guideline as the benchmark for a new wrenching method

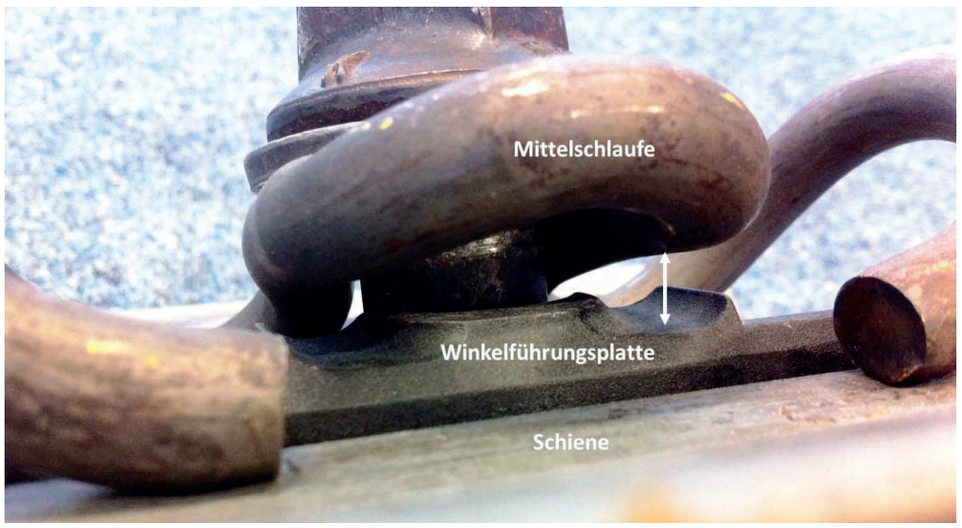


**Fig. 1:** The geometric nominal tensioning for W track is ≤ 0.5 mm as per DB Guideline 824.5050.

**Guideline Ril. 824.5050[1] of Deutsche Bahn (DB) for the production of continuous rails and tensioning of rail fasteners has the aim of safely connecting rail and sleeper and at the same time keeping the damage to sleepers as low as possible. With this objective as a yardstick, ROBEL has developed a power wrench which tensions rail fasteners with a precisely controlled torque and documents each of these operations in a traceable manner. The use of the new precision wrenches during the last few months throughout Germany has shown that the new precision power wrench has made a lasting positive change to wrenching standards at the track.**

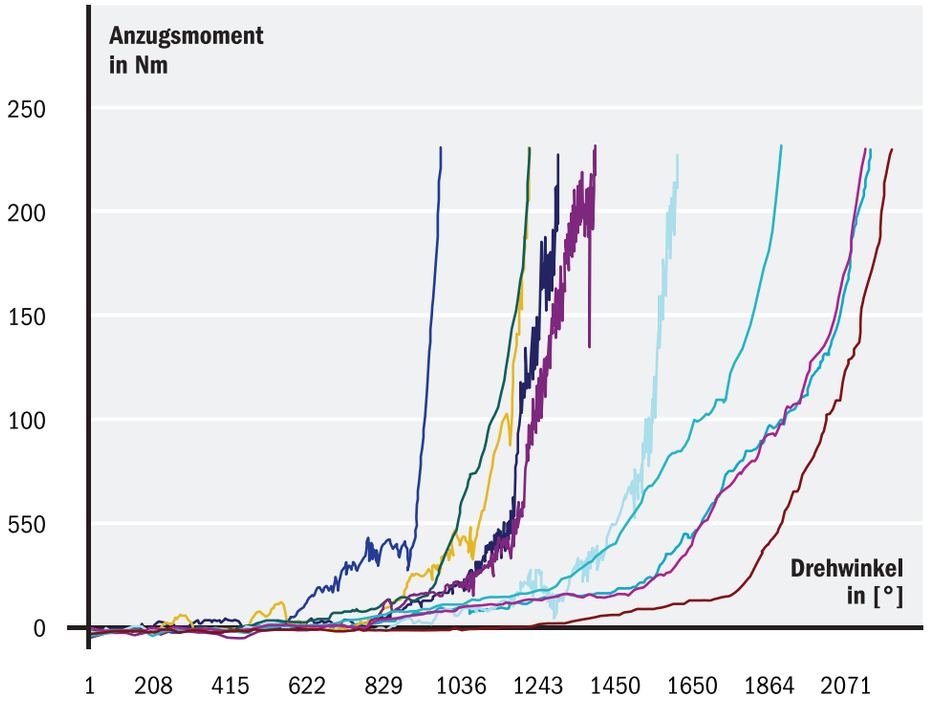


**Fig. 2:** Torque versus angle of rotation of various nuts on K track. The left-hand curves show hard screw joints; every type of lubrication shifts the curves to the right. Graphs recorded with ROBEL servo wrench.

### Background: Analysis of causes of sleeper damage

Three quarters of sleepers in the German network – in total 78 million – are made of prestressed concrete. The current damage level is about 2.5 %; close to two million concrete sleepers are, therefore, damaged by various cracks and chips[2]. Annual maintenance costs amounting to tens of millions as well as significant restrictions in network availability prompted Deutsche Bahn to analyse the causes as the basis for a quality offensive in the area of sleeper maintenance and replacement.

The focus of this offensive was, on the one hand, an improvement in the determination of faults and planning of deployments and, on the other hand, an increase in the quality of construction, installation and maintenance of the track. The clear request of DB for innovative solutions around the sleeper is based on the requirement to ensure low maintenance track and high operating quality[3] as well as on the motivation to remove the previous uncertainty regarding the cause of sleeper damage resulting from low material quality or improper handling. Clearly, it is very significant, particularly for the settlement of damages, whether cracks in sleepers have arisen due to material defects or in the course of maintenance work.

### Benchmark Guideline Ril. 824.5050

DB regards a re-assessment of the requirements for the tensioning of rail fasteners as an effective means for increasing the maintenance quality. In accordance with Ril. 824.5050, a rail is correctly fastened if the nominal geometric tensioning (clearance ≤ 0.5 mm) is provided whilst observing the maximum permissible torque of 250 Nm.

[Figure 1 from RIL/clearance]

Meeting these requirements when using conventional power wrenches presents organisational as well as cost challenges for the contractor: every hundredth (for hydraulic wrenches) or every twentieth (for mechanical wrenches) sleeper has to be checked with a torque spanner and its conformity with the rules has to be confirmed in writing. Independent of this, the railway construction supervisor also checks the proper tensioning and that the evidence has been provided.

The change to the guideline also led to better proof of compliance. In cases of complaints regarding the cause of sleeper damage, keeping records of the wrenching operation strengthens the position of the contractor towards the client as too high a torque can be excluded as the cause of sleeper damage.

1 Guideline Construction, Control, Signalling and Telecommunications Systems/Producing continuous rails and switches, tensioning fasteners, partially loosening or removing fasteners, Author: I.JPF 111(G); Stefan Balfanz. Effective 01.08.2015

2 As at 07.05.2015, DB Netz AG, 59th Track Technical Conference 12.05.2016, Heinz Siegmund, Dr.-Ing. Thomas Hempe, Source for damage level: Sleeper Damage Monitoring

3 DB Netz AG, Leitfaden „Richtiger Umgang mit Betonschwellen/ Voraussetzungen für eine lange Nutzungsdauer“ (Guideline “Correct Handling of Concrete Sleepers/Conditions for a Long Period of Use) Dr. Thomas Hempe, 2015

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## Effect of kinetic energy on the wrenching result

The energy required to tighten the screw connection varies depending on the condition of the track and of the thread surfaces.

In case of hard screw joints, e.g. old spring washers on oiled hooked bolts or soft clamps on the W track with greased dowels, the energy required is less than for clamps with high pre-tensioning with stiff threads. In addition, the different pitches of hooked bolts (3 mm) used in K track or the sleeper bolts (12 mm) of the W track are an essential factor for achieving the torque specified. [Fig. 2 Torque over angle of rotation of various nuts on W track].

The type of track and the condition of the individual bolts therefore require different procedures for tensioning to achieve a result conforming to the guideline.

Within the scope of continuous development to extend the company's wrenching competencies, ROBEL saw the limits of mechanical wrenches when used for railway construction: a large part of the kinetic energy is predetermined by the centrifugal mass which the motor delivers to the spindle via the transmission. Only a small part of this energy can be controlled via the friction coupling. If the machine is not calibrated precisely for the prevailing condition of the track, the torque at the bolts can reach peaks of up to 600 Nm. Concomitant with this is the associated material loading of screw connection and sleeper.

Consequently, the current standard procedures are suitable only in certain conditions, i.e. only for soft screw joints, to provide uniformly good quality of the wrenching result. DB derived from this finding the specification that, for new rails, the underside of the socket and the thread have to be coated with a suitable corrosion protection agent before the first tightening[4].

## Primary quantity - torque

As a result, ROBEL developed a wrench which recognises the type of screw joint and controls the torque during the final stage to a precise torque. This patented solution is based on the fact that the torque as primary quantity is determined directly at the torque support [Fig. 3 Torque support] instead of determining it as previously via secondary quantities such as current or hydraulic pressure.

The content of the patent is a new procedure based on the lever arm/force principle according to which the reaction moment at the screw spindle is recognised reliably by a force transducer, without being affected by second-order effects. In particular, the influence on the measurement value of secondary effects such as oil temperature and coupling friction are eliminated.

The system has a resolution in the Newton-metre range for the precise detection of the torque reached. In addition, the wrench documents each fastening operation in a traceable manner; the specifications of DB guideline 824.5050 are thus met. This prompted DB to exempt the 30.73 PSM precision power wrench from the specified checking of every twentieth or hundredth fastening as the only one of the twelve wrench types used by DB.

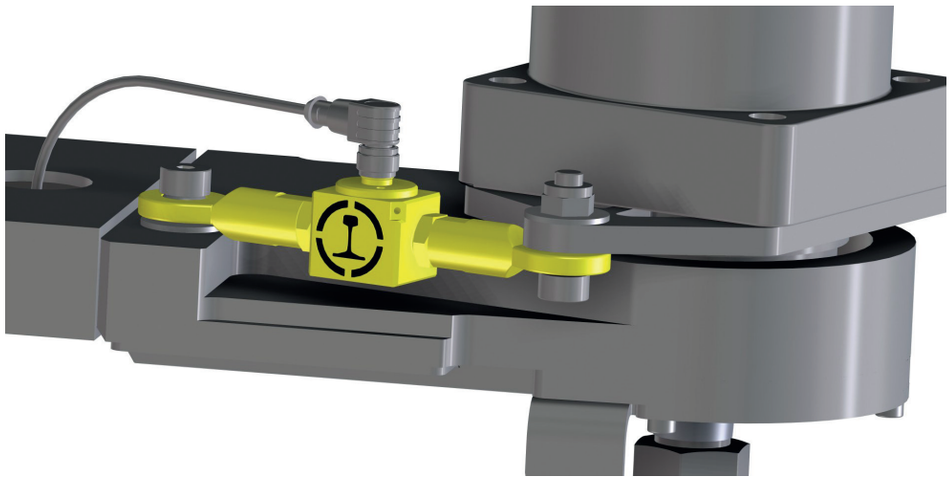


**Fig. 3:** Patented torque measurement with integral torque spanner.

## Simply wrenching – a report from the field

What makes the construction contractor expand his proven machine pool by a hydraulic precision wrench, in addition to the prescribed assurance of the correctly tensioned condition? The concrete benefit can be illustrated based on a standard work assignment.

## Objective: immediate readiness for use

Scheduled work gives the contractor the opportunity of maintaining the machines required and to send them for calibration in a timely manner. The high time pressure of unexpected jobs, however, usually does not allow any leeway for time consuming preparations. Due to their hydraulic components, the 30.73 PSM is largely maintenance-free compared to mechanical wrenches (maintenance interval 2 years or 200,000 wrenching cycles), does not have any wear parts apart from oil and filters and thus remains ready for immediate use. Calibration is carried out annually using the torque measurement unit [Fig. 4 Calibration] by trained staff of the contractor in his own workshop or alternatively at the manufacturer, and this also serves as proof of functionality for the construction supervisor.

## Objective: easy transport to the work site

For track which is difficult to access, if space is tight and for work on track for which there is no possession, every move and every kilogram matters. Thanks to conscious weight management during machine design – use of aluminium components, an air-cooled 4-stroke petrol engine and the latest generation hydraulic unit – the 30.73 PSM achieves an overall weight of about 97 kg. Transport and positioning at the track without crane and transport wagon even in

**Fig. 4:** The annual calibration is carried out by trained staff of the contractor using the torque measurement unit.

**Fig. 5:** With the handles folded in, the wrench can be transported easily by four people, even if space is tight.

difficult terrain is achievable with an ergonomic posture. [Fig. 5: 30.73 in transport position]

## Objective: intuitive start-up

For mechanical wrenches, achieving the torque required demands manual adjustment to factors such as type of track, condition of hardware, temperature and engine wear, the assessment of which is largely dependent on the judgement and experience of the operator. Once adjusted, the selected settings remain unchanged for the remaining time of operation, with a significant effect on the torque if the environmental conditions change, e.g. temperature fluctuations and different bolt conditions[5]: Too high a torque can cause sleeper damage; too low a torque results in bolts which are not correctly tensioned.

The programmable logic controller (PLC) of the hydraulic precision wrench enables the fast, menu driven adjustment of the following parameters without any prior knowledge of the operator:

- Wrenching pattern (inside or outside of rail)
- Type of track (K, KS, W)
- Line data (line/track number, kilometre number, rail) and
- Marking of the first joint


**Fig. 6:** The PLC display shows that the wrenching process has been completed in line with the guideline.

As the self-learning controller of the 30.73 PSM carries out a continuous comparison between nominal and actual value and the current screw joint and corrects the torque accordingly, the above adjustments are used mainly to optimise the work speed and result and for the precise documentation of the wrenching operation.

## Objective: continuously correct and documented wrenching result

The practicality of new technical solutions is only confirmed by use under real-life conditions. In the case of a wrench, this is the production of screw connections conforming to the guideline in the shortest possible time. The operation of the fully hydraulic 30.73 PSM described below demonstrates the technical implementation of the new wrenching method.

## Ergonomic wrenching

After setting the parameters via the softkeys of the PLC, the operator starts the wrench by lightly pressing on the right-hand or left-hand button on the handles. To increase work safety, the LED lamp fitted to the right below the handle illuminates not just the wrenching area, but the complete work area. The machine has adjustable handles and is balanced in such a way that it can be operated comfortably and without force in an upright posture.

## The learning wrench

The comparison between nominal and actual value by the self-learning wrenching program is carried out in accordance with the following control loop:

1 – The force transducer registers in the millisecond range how tightly the bolt is tightened at any point of the wrenching process and
2 – Transmits this information to the PLC.
3 – The PLC recognises the type of screw joint based on the stored gradients.
4 – The spindle speed for the final torque is precisely pre-set.

As soon as the PLC recognises that the maximum torque of 250 Nm has been achieved in sufficient time, the machine stops automatically. To save time, the speed of rotation is re-calculated for the next wrenching step. The display indicates whether the wrenching step has been completed correctly. [Fig. 6 Screenshot of PLC display] All captured data is recorded; the status of each wrenching step carried out or of each bolt skipped is recorded. If the display indicates a fault, the machine opens the screw joint and repeats the wrenching step. The reworking common when using mechanical machines, such as checking and re-tightening, is no longer required.

## Checking of completed sections

Due to the PLC controlled, dynamic process of the 30.73 PSM, it is now possible for the first time to check the torque on already tightened sections of track without having to completely release the bolts first. For this process, too, the torque measured is continuously recorded. This process is used, particularly for older track, as a fast proof of the tight fit of fastenings in line with the guidelines.

## Releasing bolts

When loosening screw joints, the torque is increased dynamically linearly up to 880 Nm. On the one hand, this protects the mechanical parts of the machine, on the other hand, the high release torque is reliably sufficient to break off rusted bolts in older K track fastenings. In addition, a process stored in the PLC and selectable via the menu facilitates loosening of tight bolts in loose W track dowels.

## Documentation safe from manipulation

When using mechanical wrenches, the checking of screw joints prescribed in Ril. 824.5050 with the 1% and 5% rules is carried out manually with a torque spanner on every 100$^{th}$ or 20$^{th}$ sleeper and is documented. This time-consuming procedure is not required for the precision power wrench due to the automatic recording of the coded wrenching results. The digital record is output via a protected, waterproof USB interface. The vibration and temperature resistant USB stick can be read by common Office programs without additional software or readers.

**5** See Fig. 2 Torque versus angle of rotation on K track

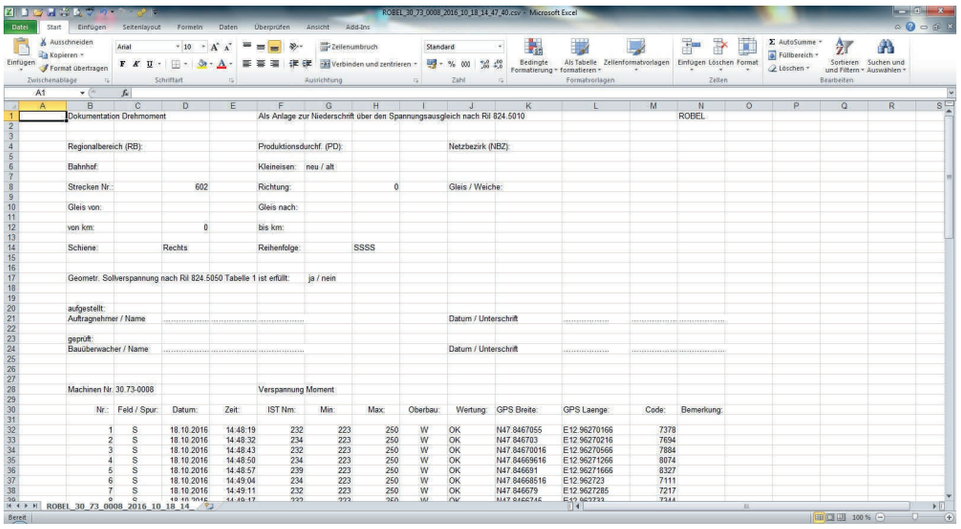
## Optimum evaluation by GPS

If required, the 30.73 PSM can be fitted with a GPS data logger. In this case, the record also shows the GPS position for each screw joint on the same line [Fig. 7 Record with GPS data]. Possible faults in the track fastening are thus quickly located without doubt and can be rectified [Fig. 8 Google Maps with GPS data].

## Precision wrenching in Germany

As the new guideline has come into force, the landscape has changed. The prescribed checks and documentation of each screw joint as a rule means additional staff and time for the contractor. This results in costs which do not arise when using the fully hydraulic precision wrench. Furthermore, the new wrenching method leads to savings in areas which have been a fixed part of all wrenching work on the track up to now, such as external calibration, set-up costs and continuous reworking.

The 30.73 PSM precision wrench provided its first proof of performance on the Kassel-Hanover high-speed line in April 2016. After nine months of widespread field operations, the potential of precise wrenching has become apparent.



Dokumentation Drehmoment — Als Anlage zur Niederschrift über den Spannungsausgleich nach Ril 824.5010 — ROBEL

| Nr: | Feld / Spur: | Datum: | Zeit: | IST Nm: | Min: | Max: | Oberbau: | Wertung: | GPS Breite: | GPS Laenge: | Code: | Bemerkung: |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | S | 18.10.2016 | 14:48:19 | 232 | 223 | 250 | W | OK | N47.8467055 | E12.96270166 | 7378 | |
| 2 | S | 18.10.2016 | 14:48:32 | 234 | 223 | 250 | W | OK | N47.846703 | E12.96270216 | 7694 | |
| 3 | S | 18.10.2016 | 14:48:43 | 232 | 223 | 250 | W | OK | N47.84670016 | E12.96270566 | 7884 | |
| 4 | S | 18.10.2016 | 14:48:50 | 234 | 223 | 250 | W | OK | N47.84669616 | E12.96271266 | 8074 | |
| 5 | S | 18.10.2016 | 14:48:57 | 239 | 223 | 250 | W | OK | N47.846691 | E12.96271666 | 8327 | |
| 6 | S | 18.10.2016 | 14:49:04 | 234 | 223 | 250 | W | OK | N47.84668516 | E12.962723 | 7111 | |
| 7 | S | 18.10.2016 | 14:49:11 | 232 | 223 | 250 | W | OK | N47.846679 | E12.9627285 | 7217 | |

**Fig. 7:** The data log shows all wrenching results during the operation, listing the GPS data of each screw joint.

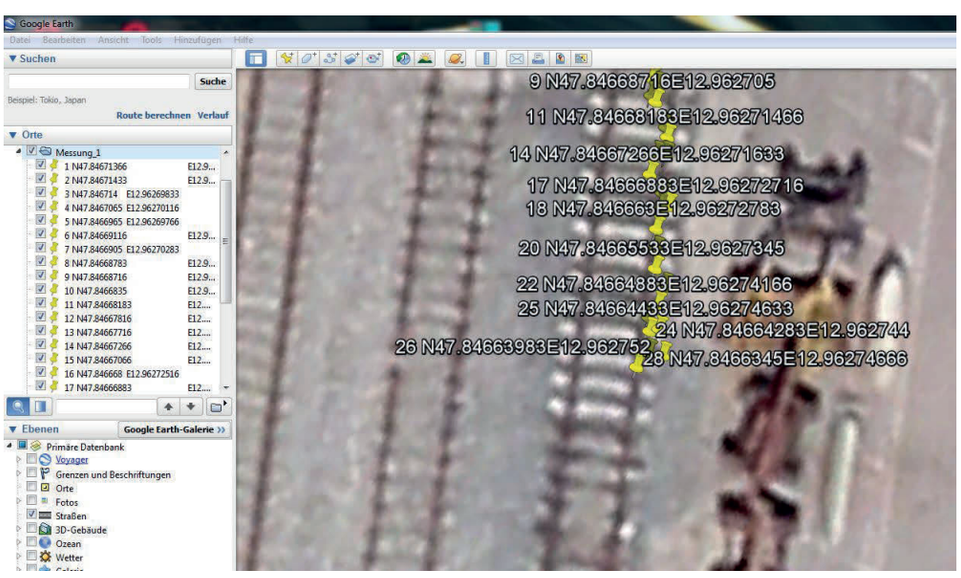



**Fig. 8:** Transferring the recorded GPS data onto Google Maps facilitates locating possible faults in track screw joints.

| TECHNICAL SPECIFICATION of the 30.73 PSM precision power wrench | |
|---|---|
| Drive | air-cooled 4-stroke petrol engine |
| Type | HONDA GX200 |
| Wrenching parameters | Speed (tightening and loosening) adjusted automatically (max. 205 rpm) |
| | Loosening torque max. 900 Nm |
| | Tightening torque depending on machine version, max. 500 Nm |
| Torque as per DB Ril. 824.5050 | 250 Nm |
| Dimensions (L x W x H) | Transport position 1530 x 470 x 960 mm |
| | Working position 2090 x 470 x 960 mm |
| Weight | ~96.5 kg, machine |
| | ~6 kg, running gear |
| | ~3.5 kg, outrigger |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**REFERENCES**

[1] Guideline Construction, Control, Signalling and Telecommunications Systems/Producing continuous rails and switches, tensioning fasteners, partially loosening or removing fasteners, Author: I.JPF 111(G); Stefan Balfanz. Effective 01.08.2015

[2] DB Netz AG, 59th Track Technical Conference 12.05.2016, Heinz Siegmund, Dr.-Ing. Thomas Hempe, As at 07.05.2015, Source for damage level: DB Sleeper Damage Monitoring, as at 07.05.2015

[3] DB Netz AG, Guideline "Correct Handling of Concrete Sleepers/ Conditions for a Long Period of Use" Dr. Thomas Hempe, 2015





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