Modern technologies in design, construction and maintenance of railway turnouts – Experiences with Turnout Refinements (ÖBB)

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Following the principles of an economic track, several track components in several basic and maintenance conditions and with different service lives need to be taken into account.

The cost driver on the Austrian track system is clearly identified. It is the yearly de-preciation of the assets, followed by operational hindrances and maintenance costs.

Therefore 2 main strategies for an economic track are obvious:

- The initial quality must be the best possible and
- Doing proper maintenance to extend service life is the best you can do

By the way, ÖBB fully admit to an overall life--cycle-management for all kind of tech-nical and maintenance strategies!

Depending on the parameters speed, tonnage and category of line, the following rail profiles are incorporated in turnouts together with wooden or concrete sleepers: 60 E1, 54 E2 or 49 E1 rail profile.

In Light loaded tracks, ÖBB tries to re-assemble rehabilitated turnouts in combination with new wooden bearers. This method helps us to reduce costs and do a proper recycling management.

For main lines in heavy loaded tracks with more than 30.000 Gross Tons/day or in tracks with a speed of more than 160 km/h, turnouts with 60 E1 rails and concrete bearers with under sleeper pads are standard in Austria. In tracks between 10-30.000 GT/day, we prefer the 54 E2 rails with concrete or wooden bearers (depending on the material of the adjacent track sleepers).

Tracks with less than 10.000 GT/Tag are regularly installed with 49 E1 rail profiles and wooden bearers.

For the last 15 years, ÖBB introduced a lot of technical innovations in turnouts together with our contractor voestalpine to increase service live and to reduce maintenance cost for a better life-cycle-performance:

2000: New hydraulic force transmitting system "HYDROLINK®" in the track center substituting the mechanical connection rods for a better track stability. New inductive obstacle detection of the switch – IS 2000 and the first prototype of the integrated switching system HYDROSTAR®

2002: 1st test trials for concrete bearers with under sleeper pads.

2005: Introduction of a hollow steel sleeper for better tamping and track geometry quality and a new, encapsulated locking device substituting the old clamp-lock, called „SPHEROLOCK".

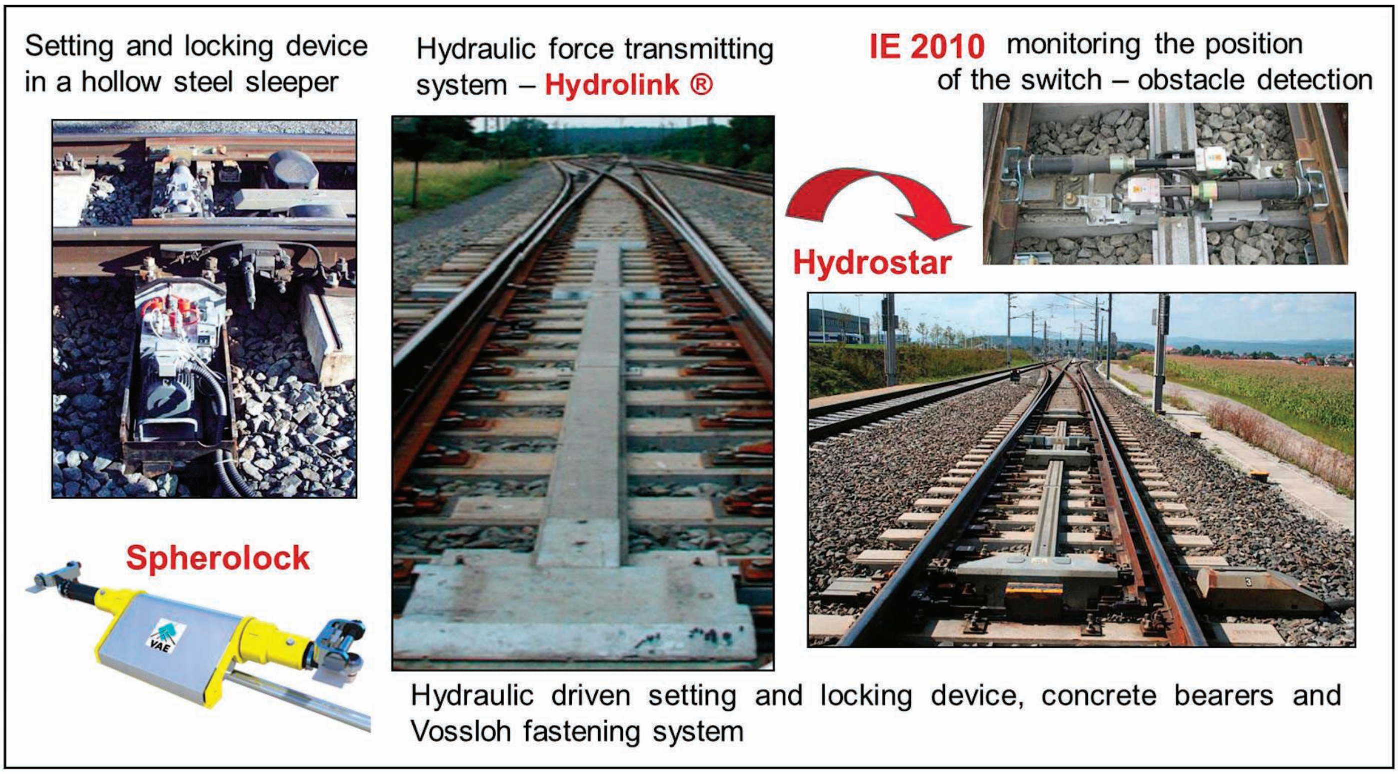
2006: Hydrostar technology became standard for all high speed tracks with 200 km/h or above.

2007: all turnouts are equipped with a so called "Carrying capacity-optimized tongue geometry (TOZ)" to improve service life span of a switch. The big ones (EW 1600/2600 and EW 10.000/4000) are carrying instead of TOZ a special kinemat-ic gauge optimization (FA-KOP) . The rail inclination was changed to 1:40 throughout the whole turnout, to fulfill TSI Infrastructure requirements.

To reduce costs, a direct fastening system from Vossloh was introduced in the clo-sure and crossing panel together with integrated switch rollers on the bearers to in-crease availability. Additionally, the Steel grade R350 HT was applied in all 60 E1- and 54 E2-turnouts and under sleeper pads for all 60 E1-turnouts.

2011: the Carrying capacity-optimized tongue geometry was adopted also for 54 E2- und 49 E1-turnouts as well as the steel grade R350 HT.

Last but not least, a new electro-mechanical monitoring system for the switch position



- IE 2010 - became standard.

The Austrian Federal Railways assemble turnouts for speeds of 200 km/h or above with a so called "common crossing with moveable point". This technical solution en-sures a continuous running of the wheel at the point, a dramatically reduced noise emission and ground born vibration and a much better track quality and durability throughout the entire service life.

ÖBB has solved the problem of the bending and inclining of the turnout from its be-ginning to the end with increasing exposure time. Since 2002, we successfully apply Under Sleeper Pads underneath the bearers for more than 800 turnouts. The reduc-tion of the ballast bed stresses and the much better elasticity causes a better track geometry, reduced maintenance actions (particular tamping) and costs. Three differ-ent elasticity's of the under sleeper pads within one turnout result in a constant set-tlement at different bedding conditions throughout the whole turnout.

The Under Sleeper Pads reduce settlements dramatically and gives a better track durability!

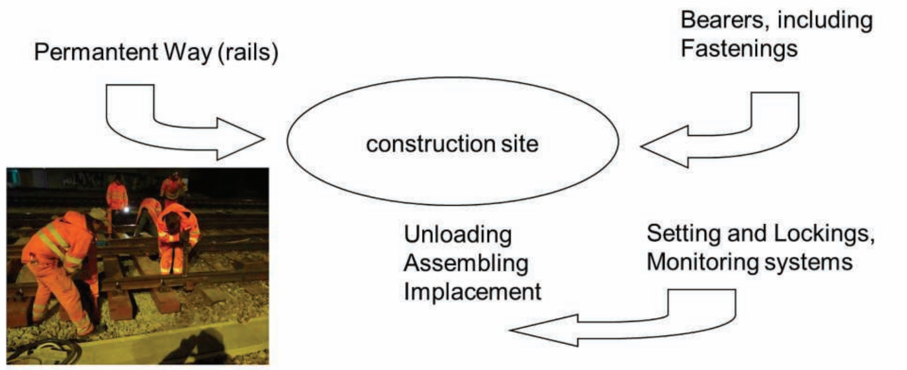
Today, modern turnouts are assembled with all combination of modules for setting, locking and position monitoring completely at the plant. This "plug and play turnout" can be delivered by special tilting wagons to the construction site just in time.

The in-placement with crane on a pre--compacted ballast bed shortens installation time and reduces track possession.

From the early beginning, the laying of turnouts (S&C) has been done manually at the construction site according the following process:

The rails, bearers, setting and monitoring system are delivered to the construction site, unloaded and assembled with a lot of manual employees directly at the con-struction site. Today, modern turnouts are assembled with all combination of modules for setting, locking and position monitoring completely at the plant. This "plug and play turnout" will be delivered by special tilting wagons to the con-struction site just in time. The unloading and installation is done by big railway cranes. After connecting to the interlocking and the welding of the rails, the turnout is ready to start operation.

S&C laying with tiliting wagons and crane has



only small economic advantages, but

- increases S&C quality (pre-assembly at the plant)
- increades quality for S&C laying
- reduces installation time
- shortens track possessions and gives a
- higher service life due to better initial quality

Last year öBB installed around 70% of all 49E1/54 E2 turnouts and 98% of all 60E1 turnouts with tilting wagons and cranes!

Especially HS tracks require a deliberate and optimized maintenance concept due to the high degree of mechanization – e.g. ETCS, GSM-R, fire doors, and so on.

Together with Robel Bahnbaumaschienen, ÖBB has developed a Mobile Mainte-nance Unit for inspection and minor maintenance works on the track like welding, screwing or changing isolated joints for example.

The advantages are of major importance:

- Due to all-round protection, the highest safety for maintenance workers are guaranteed
- A high working quality can be assured due to an optimally timed operation of machines and tools integrated in the unit
- The entire work area is illuminated
- The wind and weather protection enlarges working time and increases safety at work

One of the most interesting benefits is the protection of the workers from aerodynam-ic effects of passing trains. That's why no speed restrictions occur on the nearby tracks in case of maintenance works. Let me finally summarize:

There are 2 main strategies for an economic track:

- we insist on best initial quality for track components and track laying and
- extending service life by doing proper maintenance is required

The main refinements in turnouts are

- 60 E1-rails with concrete sleepers and USP
- high quality driving, locking and detection system
- completely pre-assembled at the plant and a
- mechanized installation with cranes and tilting wagons ◀

Vehicle-based assessment of frog wear
Modern measuring systems allow new inspection concepts

Ulf Gerber, Andreas Zoll, Wolfgang Fengler

This paper considers a new diagnostic technology for an objective assessment of frog wear.

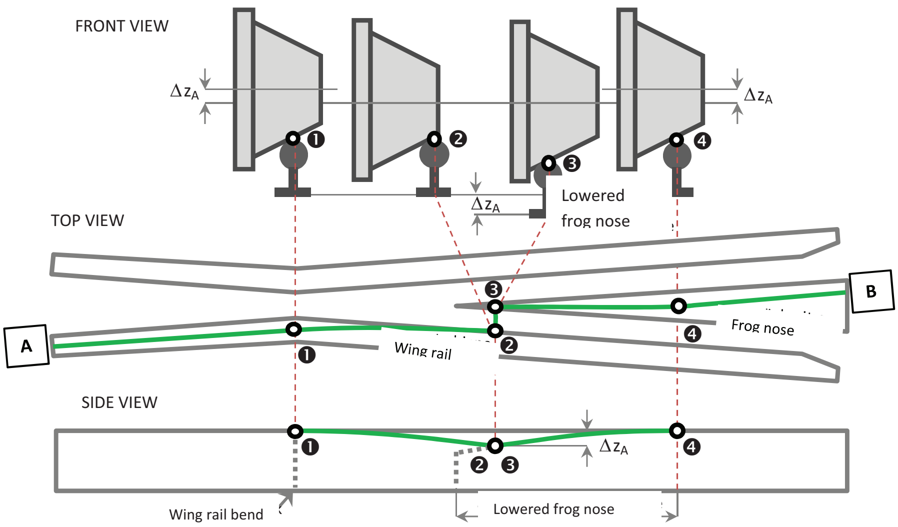
Wheel transfer geometry: Construction and wear

Figure **1** illustrates how a vertical relative movement between wheel and rail occurs in the wheel transfer area *1-4* of turnout frogs with a fixed nose. This relative movement is subdivided into a wheel movement and a rail movement. For easier understanding, the rail support shall first be assumed to be rigid. The wheel movement is thus identical to the relative movement. On its way from point A to point B the wheel-rail contact point moves horizontally outwards from the wing rail bend *1* onwards. Due to its conicity, the wheel runs vertically lower to an increasing extent. It reaches its lowest position at the point of wheel transfer from the wing rail to the frog nose. There the transfer point/contact point suddenly changes from an outer running surface position *2* (in contact with the wing rail) to a running surface position *3* near the wheel flange (contact with the frog nose). To avoid that the lateral jump causes a vertical jump, the level of the frog nose is reduced to the level of the transfer point *2/3*, starting well before the transfer point. In its further movement, the wheel resumes its original vertical and lateral position *4=1* relative to the rail. Practically, however, the track is elastically supported. Thus, what is called wheel movement is actually the relative movement between wheel and rail.

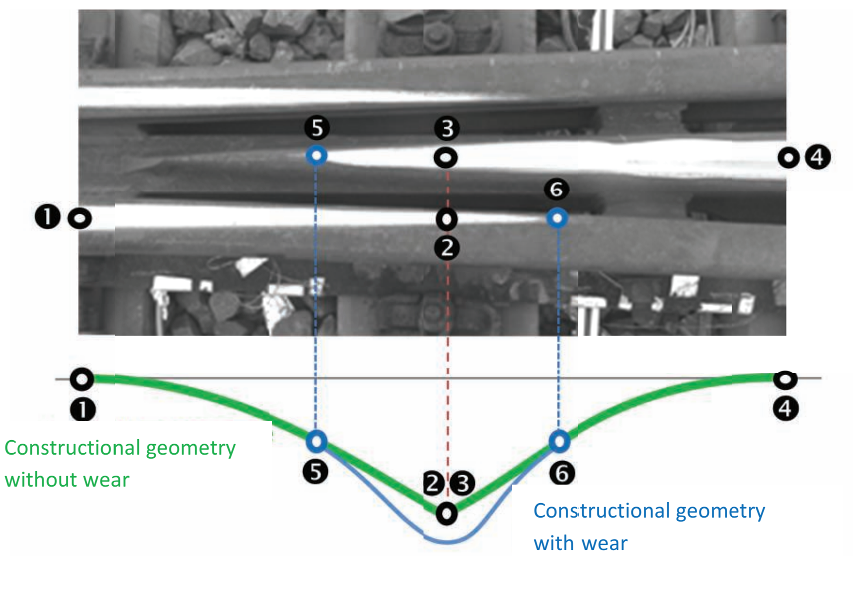
Due to the conical wheel profile, the unavoidable lateral movement of the wheel-rail contact point results in a construction-related vertical relative movement between wheel and rail. The elastic rail support in turn results in a simultaneous vertical rail movement and a related vertical wheel movement.

Figure **2** illustrates that the wheel transfer area *1-4* includes an area of wear *5-6* where the accumulated load forms a wear trough, also called a saddle. This adds a further vertical relative movement between wheel and rail.

The constructional frog geometry (Figure **1**) and the wear geometry (Figure 2) superimpose each other, resulting in the wheel transfer geometry which depends on frog design, manufacture and accumulated load.



1. Constructional geometry (schematically)



2. Wear geometry (schematically)

Dynamic wheel force as a function of speed and wear

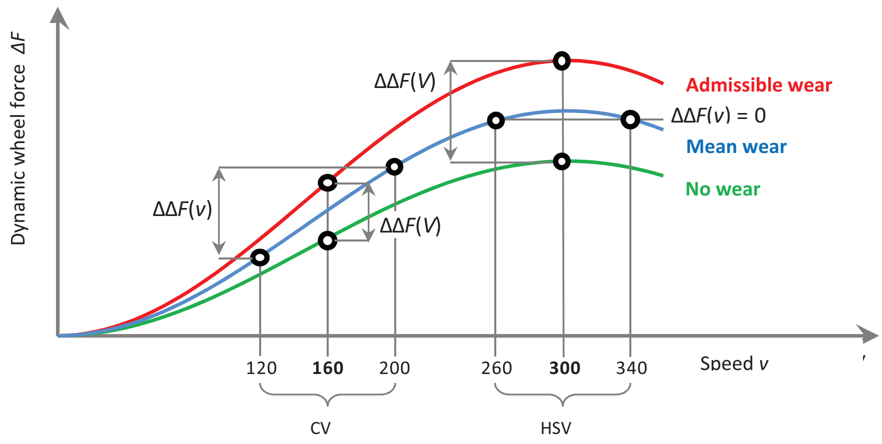
The vertical relative movement between wheel and rail related to the wheel transfer geometry results in a characteristic movement of the wheel-rail system.

Figure **3** clearly shows the great influence of wear at high speeds. Inherently, new frogs exhibit no wear. The minimal dynamic additional force is generated solely based on the constructional geometry (green line). As accumulated transport mass increases, wear and thus the dynamic additional forces increase (blue and red lines). In the conventional speed range (CV; 120-200 km/h) a speed increase by 80 km/h results in an increase of dynamic wheel force which is greater than the increase of wear from the green to the red curve . At high speeds (HSV; 260-340 km/h), the situation is vice versa. While a speed variation of 80 km/h causes almost no change in dynamic wheel force, the effect of wear on the dynamic wheel force is doubled. That is why the monitoring of rigid frogs is of particular importance in the high-speed range.

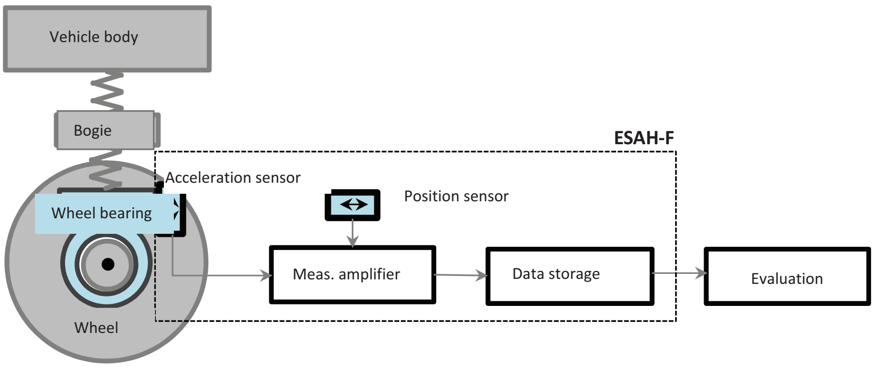
Vehicle-based inspection

It is not by chance that a trend towards vehicle-based inspection can be observed. More and more track data are captured and evaluated by specialised inspection vehicles because this reduces the expense in terms of human and material resources as compared with the conventional rail-bound inspection.

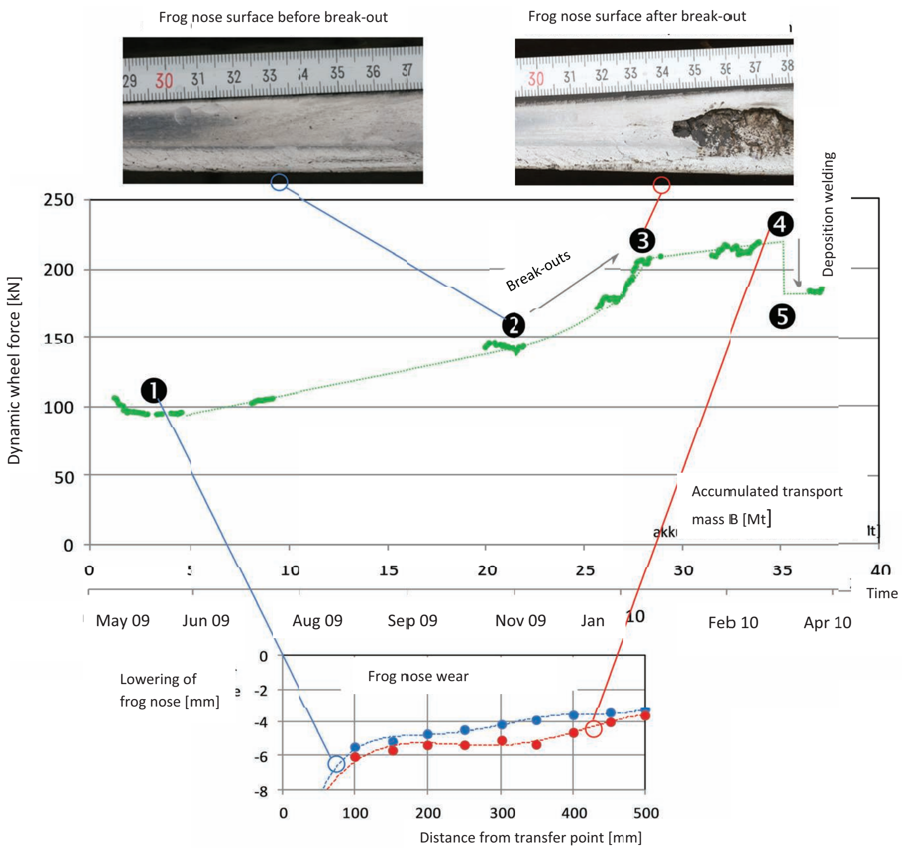
In the case of vertical frog assessment, there is one special characteristic. Every time the



3. Influence of frog geometry and speed on the dynamic additional force (schematically)



4. Measuring system ESAH-F



5. Passing over the frog at a speed of 140 km/h (ESAH-F)

frog is passed, the lateral track play results in a random trajectory of the wheel-rail contact point, which manifests itself only in a statistically describable dynamic wheel force. This requires a higher measurement rate [measurements/unit of time] than the classical inspection interval. This problem will be eliminated when the ESAH-F system is used as it is not deployed in special inspection vehicles but in regular trains.

The measuring system ESAH-F (Figure **4**) consists of an acceleration sensor attached to the wheel bearing and whose signals are proportional to the dynamic wheel force. When the frog is being passed, a position sensor determines the location of wheel transfer when the wheel passes from the wing rail to the frog or vice versa. The amplified signals are stored in the data storage (hard disk). The dynamic wheel force is then determined by an algorithm in a downstream evaluation module.

Example

Figure **5** shows the development of the mean value of dynamic wheel force as a function of accumulated transport mass and time. The data dots indicate continuous measuring operation, the free areas being measurement intervals. To illustrate the characteristic behaviour, the progression of the dotted line has been completed.

4 typical phases can be seen. Phase *1-2* is marked by a steady development of wear. However, in phase *2-3*, wear results in break-outs and thus in a strong increase in wear after a transport mass of 20 million tons. The new exposed remaining surface is in turn marked by a short-term steady development of wear in phase *3-4*, however, at a higher force level with an accordingly stronger growth of cracks than in phase *1-2*. To avoid further break-outs and deformation as well as a resulting increase of wheel force, the frog was deposition-welded in phase *4-5*.

For illustration, the lower part of the figure shows the lowering of the nose level of the new frog (no wear, *1*) and shortly before deposition-welding (with wear, *4*). The top part of the figure shows photographs of the surface of the frog nose shortly before the break-outs started (*2*) and immediately after the break-outs had been fully formed (*3*). It should be noted that the dynamic wheel force is not only influenced by the geometry of the frog nose, but also by the geometry of the wing rail.

By using deposition welding, it is attempted to restore the initial geometry of the frog nose and the wing rail. Based on the drop in dynamic wheel force, it can be assessed to what extent this has been successful. A reasonable time for maintenance work would have been before the onset of break-outs (*2*). As exemplified by Figure **5**, this would give a period of approx. 7 months to plan and execute the maintenance work.