Controlling RCF in switches and crossings

METHODOLOGY With cyclical preventive grinding strategies now well established for the management of rolling contact fatigue in plain line, a similar approach is being developed for regular grinding of switches and crossings.

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Rail grinding was initially developed as a corrective process to remove longitudinal irregularities such as corrugation or to restore cross-sectional profile of the rail head. Work was typically programmed when the damage exceeded defined thresholds, or when the resources were available.

Over the past decade or two, rail grinding has become recognised as a strategic element in preventive maintenance in order to control rolling contact fatigue, such as head checks on the gauge corner or squats leading to local dips. Removal of the fatigued top zone that contains surface cracks at regular intervals prevents the cracks from deepening to a dangerous degree. The grinding cycles will depend on the type and density of traffic, line characteristics and any operational conditions that influence damage growth.

Specific 'anti-head-check' rail head profiles have been adopted, which help to reduce local stresses by optimising the wheel-rail contact, and some infrastructure managers have largely moved to a so-called 'rail care' regime.

Periodic preventive grinding work has proved beneficial for virtually all types of heavily-loaded lines. High speed lines are prone to RCF as they are subjected to particularly high traction forces that damage high rails in curves and both rails in areas of strong acceleration. With heavy haul freight, axleloads greater than 25 tonnes can aggravate the development of RCF, and it was here that the first specific rail head profiles and cyclic grinding strategies were developed. Today, RCF is increasing on conventional lines, as the speeds of both passenger and freight trains are rising, and operators are making more use of the maximum axleload. Combined with slip-controlled locomotives capable of high acceleration, this is pushing the rails to the limit of their fatigue strength.

The EU-funded Innotrack research project provided more insight into the management of rail life, and working group WP 4.5 produced guidelines for the development of specific maintenance plans (RG 8.10

Above: Fig 1. Turnout rails are prone to the development of head checks as the contact area is shifted closer to the gauge corner.

Left: Fig 2. Rolling contact fatigue can develop on both the switch blade and the stock rail.

p45). These recommend grinding cycles ranging from 15 to 100 million gross tonnes, depending on local conditions, along with regular monitoring for the development of RCF. However, forward planning is essential. Although RCF defect growth is slow and can be estimated within certain limits, disruption to the maintenance programme may soon result in considerable corrective work.

Above: **Fig 3. Corrugation on a stock rail.**

Right: **Fig 4. Short wave formation on a stock rail. The switch blade has already been ground.**

Grinding in switches and crossings

Whilst the initial research focused on plain line, the results can also be applied to the maintenance of switches and crossings which are carrying a similar load. As the rails have the same characteristics, they exhibit the same wear and fatigue phenomena. Figs 1 and 2 show typical examples of RCF on a switch blade and stock rail.

As with plain line, the ideal maintenance regime would start by giving new turnouts an initial grinding to remove the decarbonised zone from the running surface and correct any irregularities arising from manufacture or installation. In view of the potential risk for head check development, grinding to an optimised target profile is beneficial. This would be followed by a regular cycle of grinding interventions over the whole service life of the turnouts. Ideally, the work plan for switches and crossings should be integrated with that for plain line grinding.

Precise evaluation of rail condition is an essential precursor to developing a maintenance strategy. The preliminary survey should record the type and dimensions of any defects in order to estimate the metal removal requirement and establish the priority at an early stage.

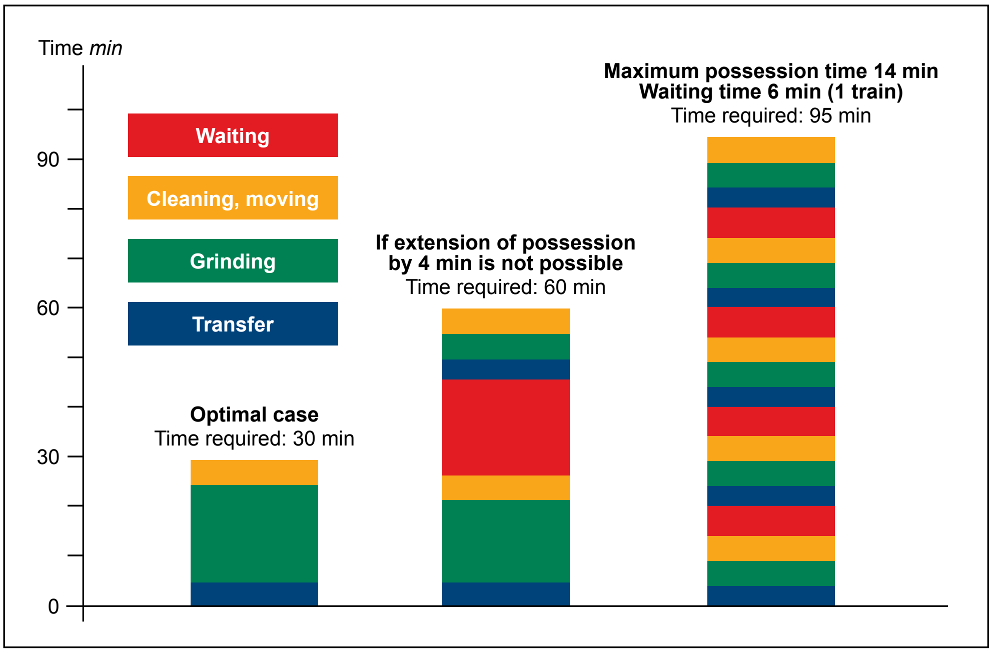
Existing measurements of defect size can provide a starting point, but a local inspection will usually be required to gather all the information needed to establish an efficient work plan. For example, a few individual switches may be finished sooner if they can be grouped together and treated in a row, even if not all of them have reached the intervention threshold. So it may be more beneficial to bring forward work originally planned for a later date.

Choosing the right stabling point can also help long-term planning. Instead of operating out of many depots grinding only a handful of switches at a time, it might be better to deal with all switches within reach of one depot at the same time to avoid time-consuming transfers to other locations.

The first step in surveying turnouts is to classify any surface defects. As well as corrugation and short wave longitudinal irregularities, the transverse profile needs to be checked for plastic deformation and wear as well as head checks and squats and single defects such as wheel burns, or welding irregularities. Figs 3 and 4 show corrugation in a switch. At the same time, it is useful to check the general condition of the turnout in case any other work such as tightening of the fastenings, tamping or welding needs to be programmed before any grinding takes place. Components such as the crossing, switch blades or stock rails which are in too bad a shape for reprofiling should be replaced.

Similarly, the rail surface condition of the rails either side of the turnout needs to be evaluated, as this can influence the length of the grinding section. It is essential to ensure a smooth transition to work already done or planned on adjacent tracks, and it may be more convenient to use the switch grinding machine on nearby tracks where track-mounted

Fig 5. The time requirement for grinding within switches can increase rapidly if individual possessions are too short.



signalling equipment or level crossings could pose difficulties for plain line grinders.

Specification and planning

In tackling RCF in switches and crossings, it is necessary to decide whether the corrective work should be completed in one visit or spread over several, which will determine the average metal removal rate. Aiming for a completely crack-free surface is complex, as RCF does not develop uniformly, but the specification of an acceptable residual crack depth after grinding looks set to be a topic of intense discussion for a long time to come.

Whilst preventative grinding of plain line can be done in one or two passes with heavy duty machines, the grinding of switches and crossings is carried out using specially-designed compact machines. Whereas the plain line grinders work at between 4 and 12 km/h, switch grinding is typically limited to about 3 km/h because of the short grinding lengths and the frequent lifting and lowering of the grinding stones.

Although EN 13231 Part 3 of 2012 provides a reference document for the acceptance of rail reprofiling work, a specific norm covering switches and crossings is now in development (EN 13231-4). However, this does not include anything about choosing an appropriate target profile, which should be the same as that adopted for adjacent tracks. Specific anti-headcheck, gauge-widening or asymmetric profiles may also be used occasionally.

In traditional turnouts, the rails are generally installed vertically, whereas adjacent plain line rails can be inclined at 1 in 20 or 1 in 40 depending on the railway. As a consequence, the contact area in the turnout is shifted closer to the gauge corner and the concentrated forces accelerate the development of head checks. This is kept under control by natural wear from passing traffic, leading to a wear-adapted profile as a mirror image of the predominant shape of the passing wheels. Any grinding work should ensure that the new or ground head profile wears towards this typical geometry.

With modern turnouts the rails are either inclined or the rail head modified to match the inclination of the adjacent track. Thus, the once-intensive debate about target profiles in turnouts has largely become obsolete.

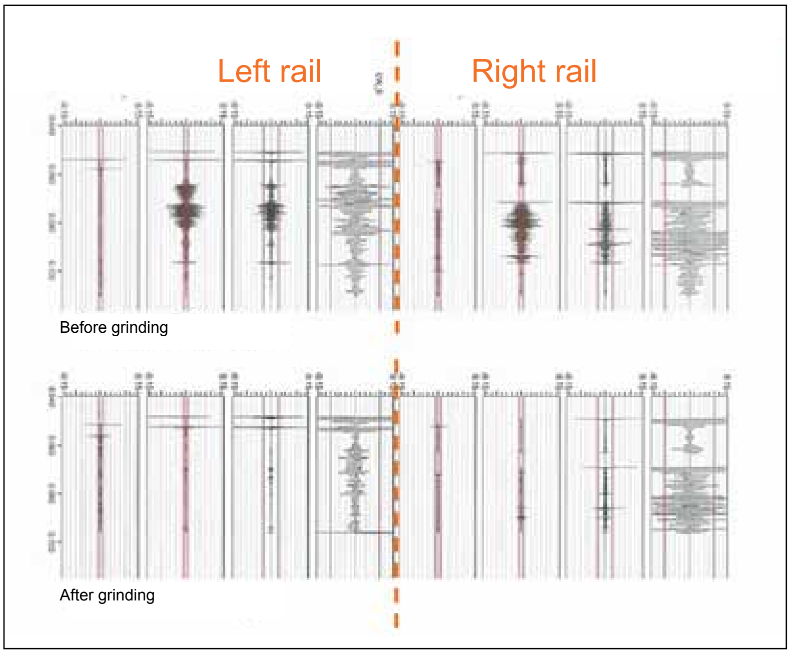
With respect to the elimination of RCF, which primarily concerns the gauge side, it is best to use a target profile with a light gauge corner relief, as profiles such as 54E5 have proven beneficial in open track. However, the discussion about gauge corner relief in switches is still ongoing, including a theoretical debate about the negative influence on equivalent conicity.

An increasingly significant challenge is getting access to the switches and crossings, particularly at busy stations or key junctions. As long ago as 1998 I suggested that it was better to try to allocate more time for switch grinding, as a 30 min possession would allow up to 10 passes at 3 km/h, whereas splitting the work would require five 15 min possessions because of the extra time needed for clearing up and moving to another worksite (Fig 5). Lengthening the possession time by 4 min could save another 15 min possession and the associated waiting time, whilst doubling the allocated time could result in a threefold increase in productivity.

Although some details have changed, this argument is still valid 15 years later. However, available possession intervals have become scarcer and shorter, and the related costs are even higher. More

Top: Fig 6. Lifting of switch blade before grinding.

Above: Fig 7. Finished ground rail in a switch.



Right: Fig 8. Recording of the longitudinal profile before and after grinding.

Below: Fig 9. Checking the wear situation at the switch blade.

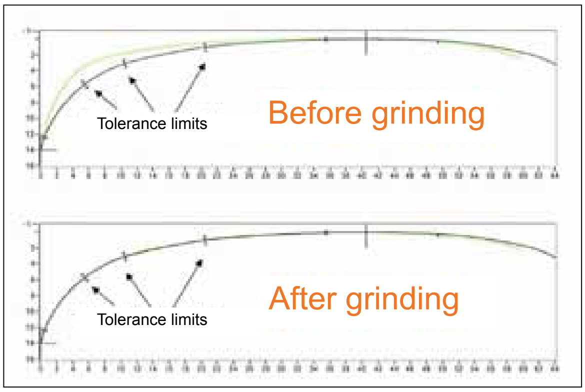


Fig 10. Transverse profile recording before and after grinding.

productive machines are helping to lower the production cost, and even if the infrastructure manager has to compensate train operators for disruption, more strategic use of longer possessions would see the overall cost reduced.

The actual grinding work on switches and crossings is not very different from plain line. However, one specific variation is the option to adjust the switch blades during grinding.

Depending on the location of the turnouts and the different traffic loads using the straight and diverging routes, wear patterns may vary significantly between the various rails. For example, if most traffic uses the straight track, this would see considerable vertical wear over time. As the switch blade only starts to wear where wheel forces transfer from the stock rail, the contact zone on the blade gradually moves forward towards the tip. And whilst the stock rail on the open side of the turnout will wear as a result of both traffic load and regular grinding, the corresponding open switch blade is less used, and its height will change very little. When the points are set for the diverging track, the switch blade on that side is higher than the stock rail, and is thus impacted by the wheel load closer to the tip.

In order to maintain the transition zone between switch blade and stock rail at the optimum location, the switch blade needs to be lifted by a few millimetres during the grinding pass, so that it is ground correctly. This can be achieved with jacks and shims (Fig 6). The blade can be lifted by between 4 and 8 mm without dismantling the drive, and the work takes little more than 5 min.

Lifting the blade ensures that the grinding stones can work on those areas which are usually contacted by the wheels. After the blade is returned to its original position, the transition zone has been moved back towards the crossing frog, where it would be when new. The same procedure can be applied in curved turnouts with a degree of superelevation, which is particularly useful for removing any short wave corrugation that can develop close to the blade tip.

Following the grinding work, it is important to undertake visual inspection and measure the longitudinal and transverse profiles to ensure the switch and crossing meets the required specification. Longitudinal profile is usually recorded in up to four different wavelength classes, as defined in EN 13231 Part 3 (Fig 8). Special measurements following switch grinding include checking the wear at the blade tip (Fig 9). Verification of the transverse profile is typically undertaken at defined points along the intermediate rails (Fig 10).

In recent times recording systems based on eddy-current technology have been introduced to detect surface cracks, particularly head checks at the gauge corner. These can be used before grinding to check the programmed metal removal requirement, and during grinding to monitor the steady reduction in RCF crack depth. If complete removal has been specified, only these recordings can confirm whether the goal has been reached (Fig 11).

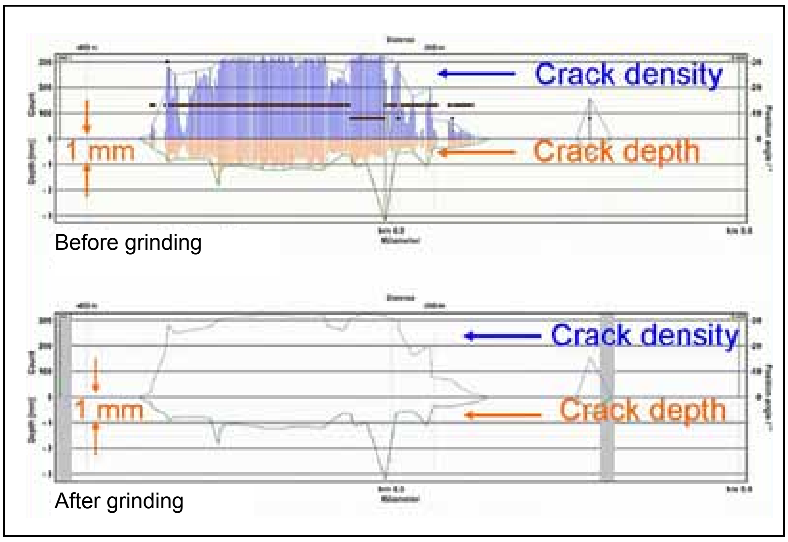
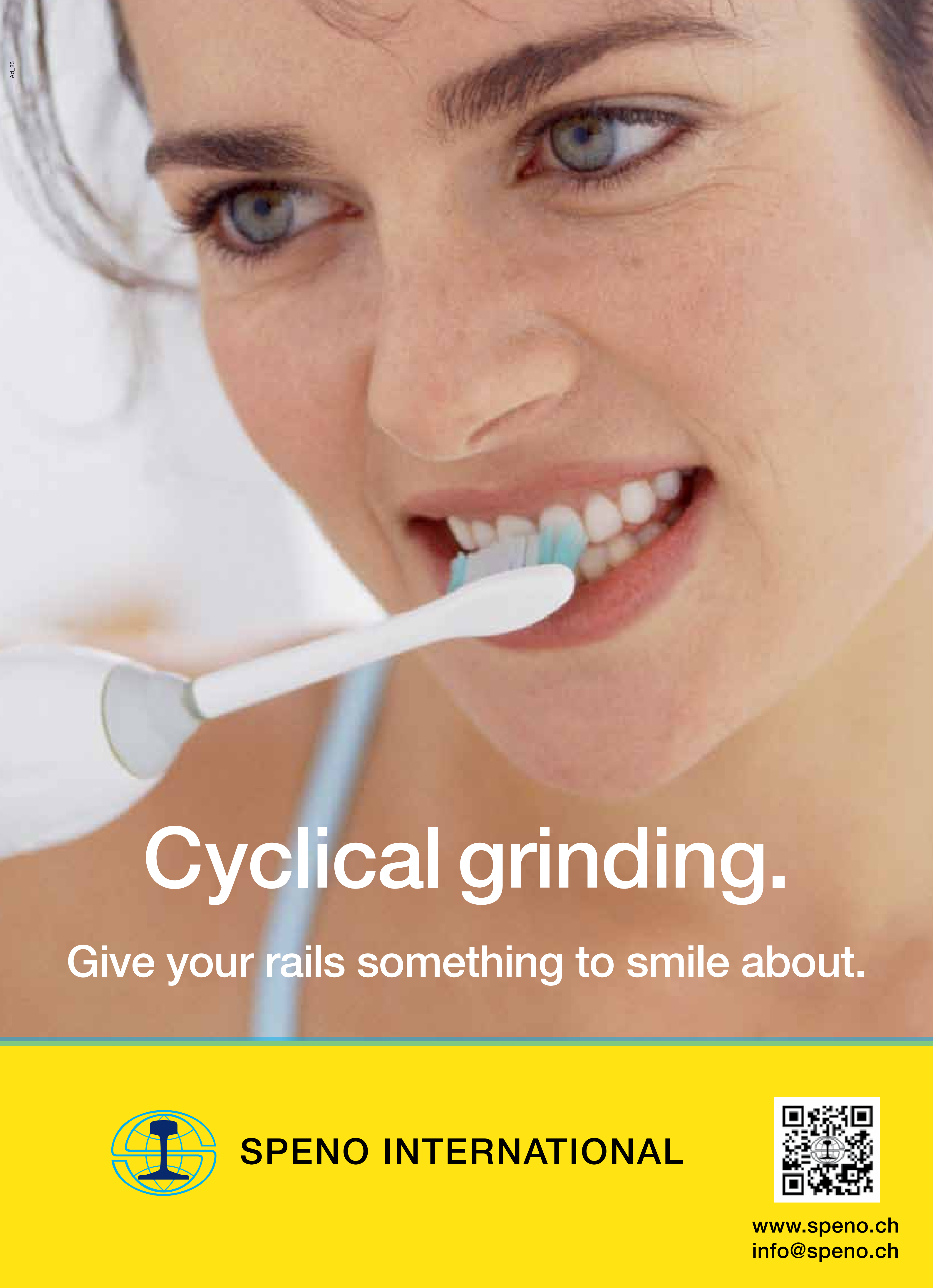


Fig 11. Head check recording with the HC grinding scanner.



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